UNUK RIVER BIBLIOGRAPHICAL REFERENCES

River Name	Agency/Author/Publication	Author	Year	Report Title
Unuk River	Alaska Department of Fish and Game		2005	Unuk River Chinook Salmon Initiative
Unuk River	The Alaska Sportsman	Gabler, F. W.	1937	Horse Power for Unuk Gold
Unuk River	Alaska Daily Empire	Alaska Notes	1920	"Joe Ulmer…"
Unuk River	Halliday, GB		2008	Stan Bishop -A True Sourdough 'Yes Bay'
Unuk River	Halliday, GB		2008	Stan Bishop -A True Sourdough 'Unuk River'
Unuk River	Halliday, GB		2008	Stan Bishop -A True Sourdough 'Placer Mining'
Unuk River	Halliday, GB		2008	Stan Bishop -A True Sourdough 'Freighting Unuk'
Unuk River	Harrington, Louise Brinck	Stories in the News Ketchikan	2006	Pioneers of Southeast Alaska 'Bruce Johnstone'
Unuk River	US Department of State	International Boundary Commission Report	1952	Establishment of the Boundary Between Canada and the United States Tongass Passage to Mount St. Elias
Unuk River	Mertie, Jr., J. B.	Mineral Resources in Alaska	1919	Lode Mining in the Juneau and Ketchikan Districts
Unuk River	Smikruk, Kathy M. and Prakash, Anupma	GIScience & Remote Sensing	2006	Monitoring Large Woody Debris Dynamics in the Unuk River Alaska Using Digital Aerial Photography
Unuk River	Rummel, Travis	Adventure Journal	2015	Exploring BC's Threatened Unuk River
Unuk River	Geological Survey Department of Canada	Wright, Fred Eugene	1905	Summary Report for 1905, Ottawa

Chinook Salmon Research Initiative

Unuk River Chinook Salmon

Unuk River Chinook Salmon Research

Overview

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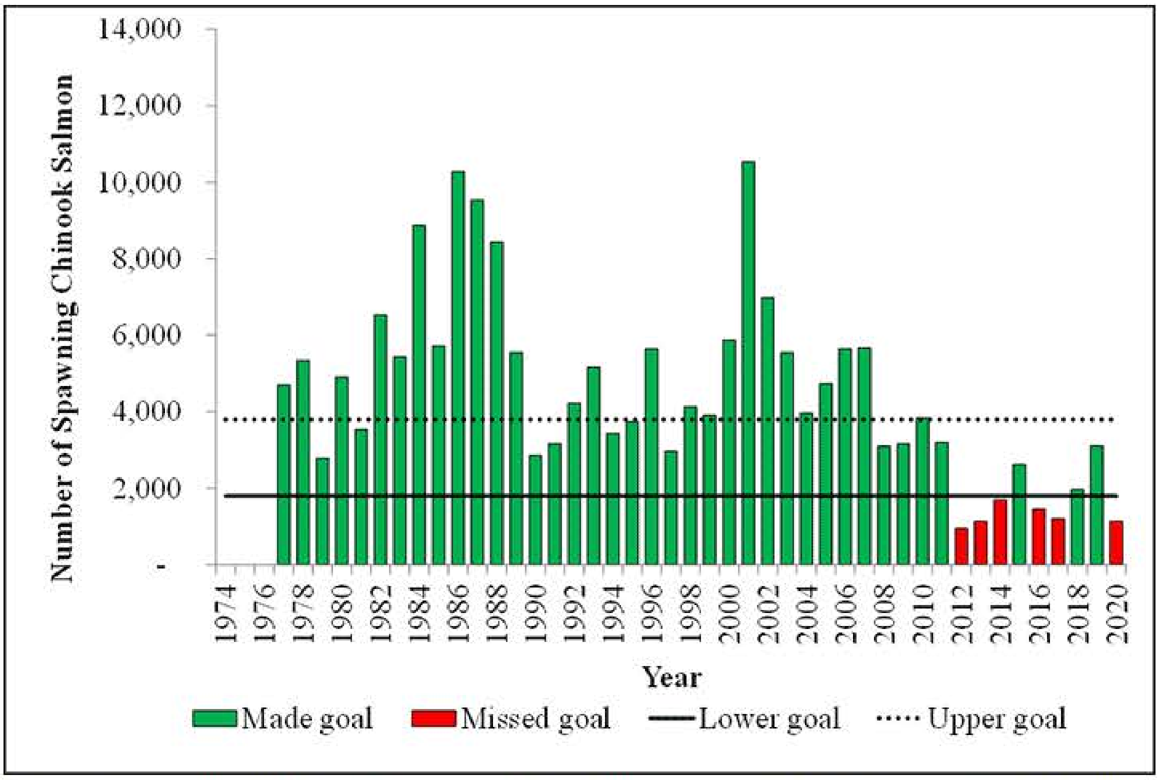
The Unuk River is a glacial system located approximately 85 km northeast of Ketchikan, Alaska. Over the past couple of decades this river has supported runs of Chinook salmon averaging about 5,000 large (essentially 28" and greater in length) Chinook salmon. After leaving the freshwater as juveniles, these fish primarily rear in or near Southeast and this stock is caught incidentally in sport and commercial fisheries in northern and southern Southeast Alaska. Data from this project are used to estimate full parent year production estimates including details on harvest, exploitation rate, and marine survival.

Spawning abundance is germane to estimates of large (essentially 28" and greater) spawning fish determined using mark-recapture studies from 1997 to 2009 and in 2011 (Hendrick, 2008) and aerial/foot surveys in 2010 and from 2012 to 2019). Prior to 1997, aerial surveys were conducted on a consistent basis in 6 clear water tributaries. Due to the loss of the set net site in 2012, there is no longer an adult Chinook salmon mark-recapture study on the Unuk River and calibrated aerial and foot surveys are used to estimate large Chinook salmon abundance.

An escapement goal of 650 to 1,400 large fish was developed for this stock in 1997 (McPherson and Carlile 1997) based off aerial surveys. After several years of mark-recapture study, this goal was updated and revised to 1,800 to 3,800 large spawning Chinook salmon in 2008 (McPherson et al. 2008).

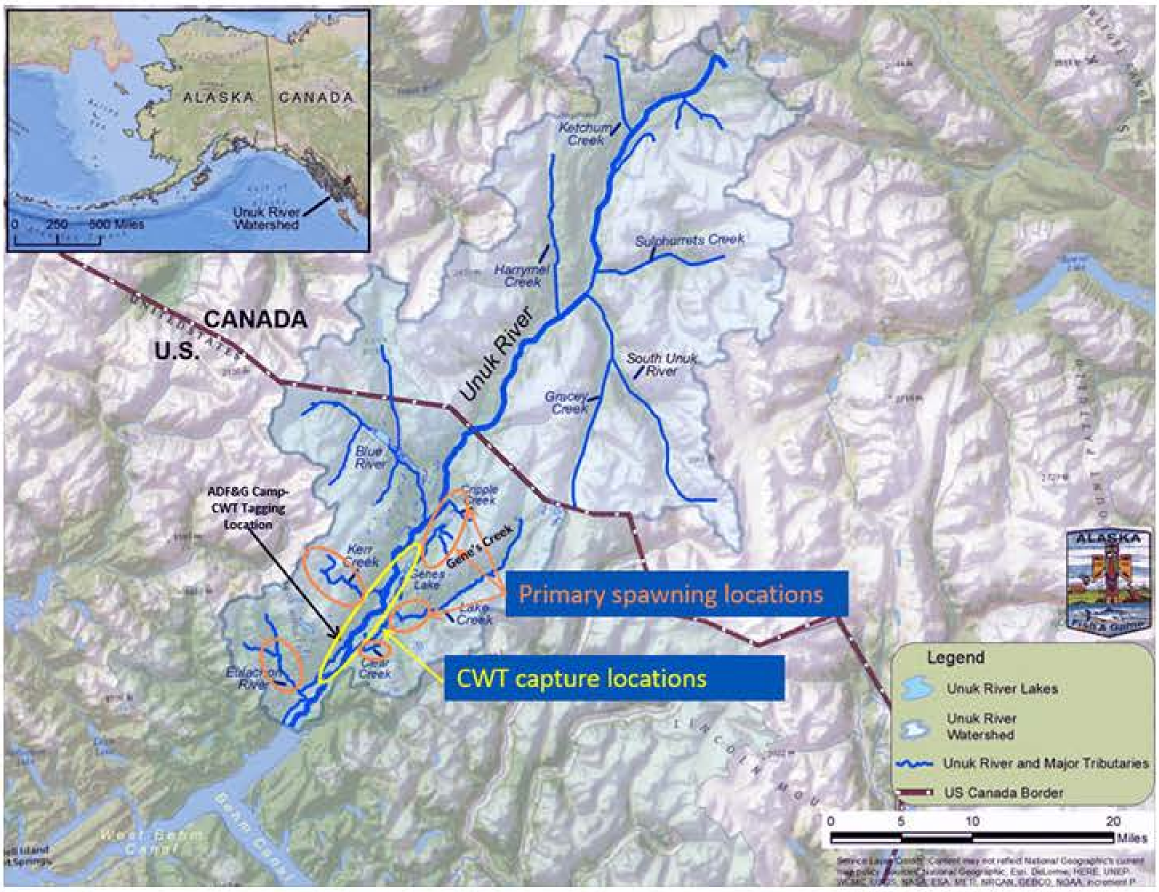
Available information on this stock suggests that about 29% of the fish are harvested annually. This stock, like others in Alaska, has recently experienced a decline in productivity. From 1977 to 2011, the Unuk River met or exceeded the lower bound of the escapement goal every year. From 2012 to 2017, the Unuk River missed the lower bound of the escapement goal in 5 of 6 years which led to its designation as a stock of concern in 2018. Escapement goals were met in 2018 and 2019. Unuk River salmon research provides fishery managers the tools necessary to manage under the sustained yield principle



Spawning escapements of Unuk River Chinook salmon, 1977 to 2020. Escapements and goals are germane to large fish (essentially 28" and greater in length).

Adult Spawning Abundance

Aerial and foot surveys are conducted annually to estimate the spawning abundance of Chinook salmon in the Unuk River. Since 1977, abundance has ranged between 956 and 10,541 large fish, with an average of 4,558 large fish. In the mark-recapture studies from 1997 to 2009 and in 2011, during June and July, marks were applied to Chinook salmon in the lower river, and at the same time, fish were sampled for tags, age, sex, and length information. Then in late July and August, marks were looked for at 6 principal spawning areas and captured fish were also sampled for age, sex, and length information. Due to the loss of the set net site in 2012, there is not currently an adult mark-recapture project on the Unuk River. Spawning grounds age, sex, and length sampling efforts have increased in August of recent years. Nearly 25% of the large Chinook salmon escapement have been sampled in 2018 and 2019 leading to higher precision in various analyses.



Chinook salmon primary spawning locations where adult sampling occurs and CWT juvenile capture locations on the Unuk River.

In addition to sampling fish for age, sex, and length information, each fish is checked for the presence of adipose fins. Fish missing adipose fins are additionally sampled for the presence of coded wire tags (CWTs) which would have been applied to fish during their juvenile life stage Sampled fish are then marked with an adipose fin clip and an operculum hole punch for a secondary mark to avoid resampling of fish and then fish are subsequently released. Fish are sampled on the spawning grounds using rod and reel snagging gear, short sections of netting and dip nets or sampled as carcasses.

Chinook salmon with an absent adipose fin.

Project operational plans are published annually to outline project methods, results, and data analyses, and are available on-line. Information gathered from this work is published in the ADF&G Fishery Data Series and is complete through parent years 2005 *(PDF 4,924 kB)*, and 2006 *(PDF 2,814 kB)*.

Juvenile Abundance

The ADF&G, Sport Fish Division, has conducted studies to estimate the abundance of juvenile Chinook salmon in the Unuk River drainage since 1994. Juvenile Chinook salmon from the same parent year are marked with adipose fin clips and tagged with CWTs as fingerlings during the fall (September and October), and again the following spring as smolt before they outmigrate to sea in April and May. Tagging in the fall and spring greatly increases the total number of tagged fish leaving the Unuk River. On average, 28,300 fingerlings and 9,623 smolt have been tagged each year and smolt abundance has ranged from 165,000 to 767,000 since 1994.

Fall fingerlings and spring smolt are captured primarily using minnow traps baited with disinfected salmon eggs. After juveniles are captured, they are transported back to camp and are anesthetized, marked, coded-wire tagged, and held for 24 hours to assess retention of CWTs and ensure they are healthy prior to release back into the appropriate habitats.

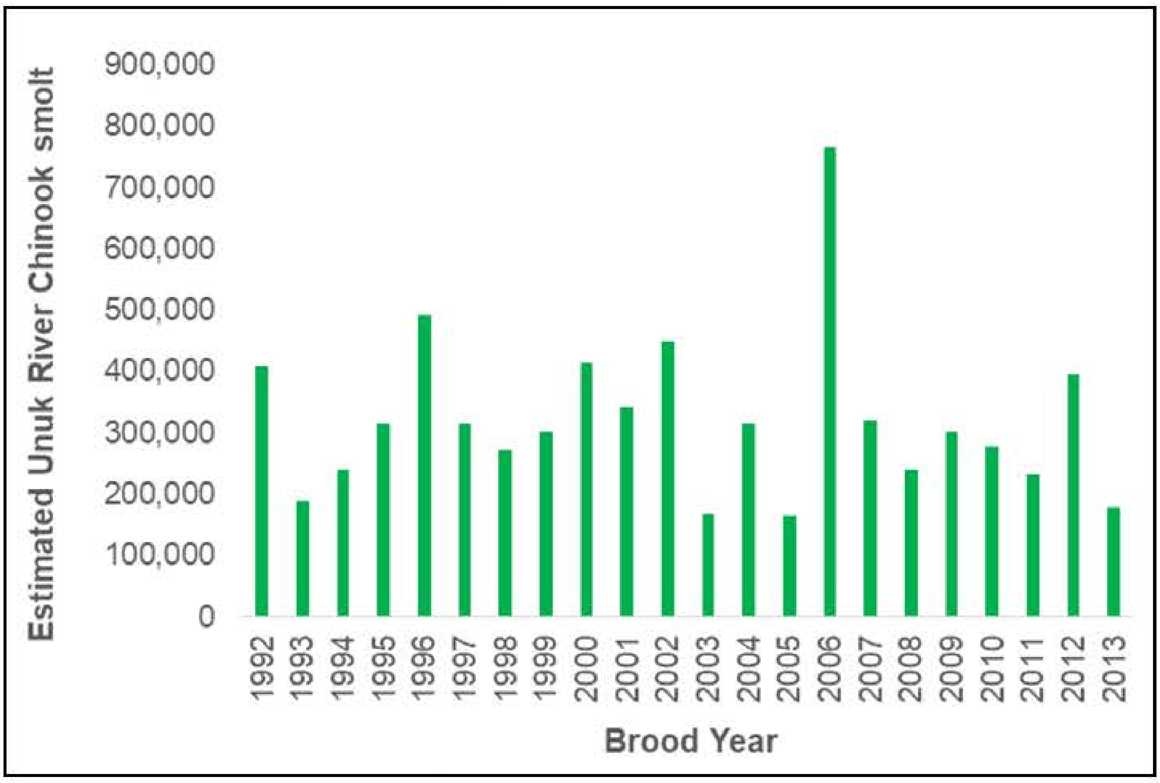
Fall work begins in late September and spring work begins in early April and runs through early May. Trapping occurs exclusively in the main stem and side sloughs of the lower river.

Unuk River Chinook salmon rear at sea from one to five years and information accumulates annually on these parent year releases as returning adults are sampled. Information of the fraction of fish marked with adipose fin clips is used in combination with adult sampling information to estimate smolt abundance. In addition, the fraction of these fish possessing valid CWTs released in the Unuk River is used to estimate adult harvests in the various marine commercial and sport fisheries. The estimated harvest of a parent year is coupled with estimates of the parent year spawning abundance to reconstruct the complete return.

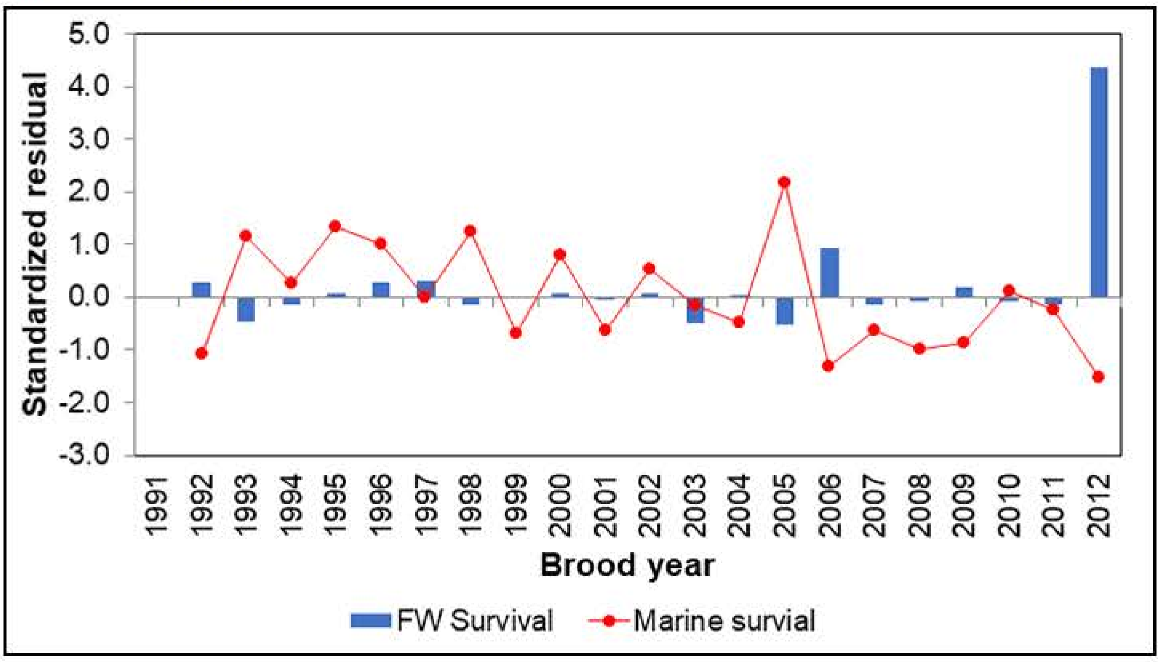
Data collected from CWT recoveries, when combined with adult spawning abundance estimates, allows for complete parent year run reconstruction, including marine harvests, smolt abundance, and marine survival of Unuk River Chinook.

To learn more about how the department conducts this research Project operational plans are published online annually to outline project methods, results, and data analysis, including the most recent plan which covers the 2017 to 2018 field season. The 2019 to 2022 operational plans are *in press*.

2017 to 2018 field season. The 2019 to 2022 operational plans are in press.



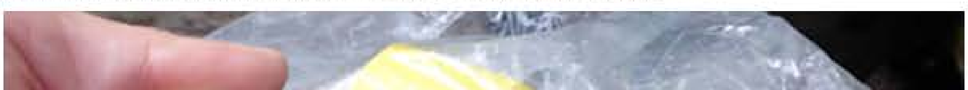
Unuk River Smolt abundance for brood years 1992 to 2013.

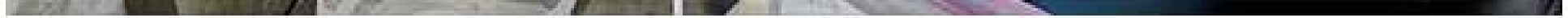


Unuk River freshwater and marine survival for brood years 1992 to 2012.

Minnow trapping in the Unuk River drainage.

Coded-wire tagging juvenile Chinook salmon in the Unuk River drainage.

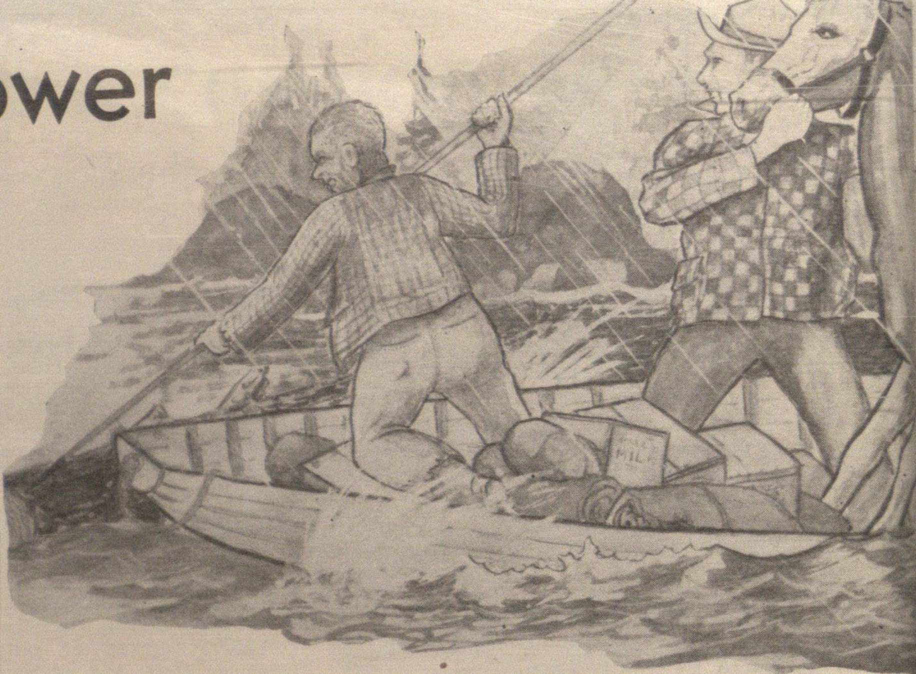




Coded-wire tagging juvenile Chinook salmon in the Unuk River drainage.

Cinch strap applied to a Chinook salmon head before it is sent to the tag lab for coded wire tag extraction and decoding.

Horse Power for Unuk Gold



By F. W. Gabler

THE conquest of Alaska's gold has been written in bold letters on the pages of the Territory's history—many times in the crimson blood of unfortunate prospectors. Hair-raising experiences, tragedy, hardships, back-breaking toil—these are common to the life of those who struggle to wrest from Nature's rugged grasp her wealth of precious minerals.

Fired with the romance of the undertaking and inspired by exciting rumors, thousands have thronged to Alaska—to them the rainbow's end where the proverbial pot of gold is waiting. In their delusion, many even expected to find shining nuggets scattered in profusion on the ground or to see sand bars glittering with the yellow dust.

In the conquest, few have emerged victorious. Thousands have failed, yet the magnetism of the word "gold" continues to draw and lure the stalwart prospector on and on to new fields, always confident that some day he will strike the pay streak that haunts his dreams.

Startling tales of harrowing experiences have devolved from the pursuit. Strange yarns, told by grizzled and weather-hardened prospectors, have come from the rivers, the mountains, the ocean beaches and the placer grounds. Few, however, are more adventureful than the stories told by the river people who have relentlessly sought the mineral deposits in the Unuk River's stronghold.

The Unuk flows from British Columbia into Southeastern Alaska. The mouth empties into Burroughs Bay, seventy miles by water from Ketchikan. Winding between towering mountains and cutting its way through beautiful valleys and canyons, the swift, shallow river has deposited her glacial silt and sands for centuries at the mouth, forming a wide delta which renders it inaccessible to navigation from salt water except on high tides. Small power boats can then proceed up one of the sloughs a short distance to the ranches of Harvey Matney and the Bishops.

From the ranches, supplies, men, and equipment must be transported on up the main river by means of shallow draft river boats, propelled by outboard motors—aided at times by pike poles and hand-lines across the bars.

The river boats are of very light construction, generally from twenty to thirty feet in length, drawing only three to five inches of water when loaded. In them, loads weighing as much as four thousand pounds have been transported long distances in single trips.

FOR years, Thomas, always known as Tom or Tommy, McQuillan, has prospected the Unuk River Valley. Few men know it as well. Eventually he found his much-sought pay dirt and, with associates, organized the Unuk River Placer Gold Company, Incorporated.

The mining property lies forty-eight miles up the river, twenty-four miles across the International boundary into Canada. Of that long, dangerous water route, only twenty-four miles is navigable to even the small river boats. When the half-way point is reached, the cargo must be packed the rest of the way through rugged country, covered with dense, almost jungle-like vegetation.

From the boundary to the Premier Gold Mining Company's Unuk River property in Canada, the Canadian Government has built a trail. This year, after years of earnest petitioning on the part of prospectors and businessmen, the Territorial Government was induced to build a trail on the Alaska side to join the Canadian trail. Only eight miles of this trail was completed this year, however, and this part is at the boundary end.

The back-breaking task of transporting heavy pieces of machinery and supplies over the trail by brute strength and grim determination is not only slow, but expensive as well. The Unuk River Placer Gold Company would need equipment to test its ground. What then?

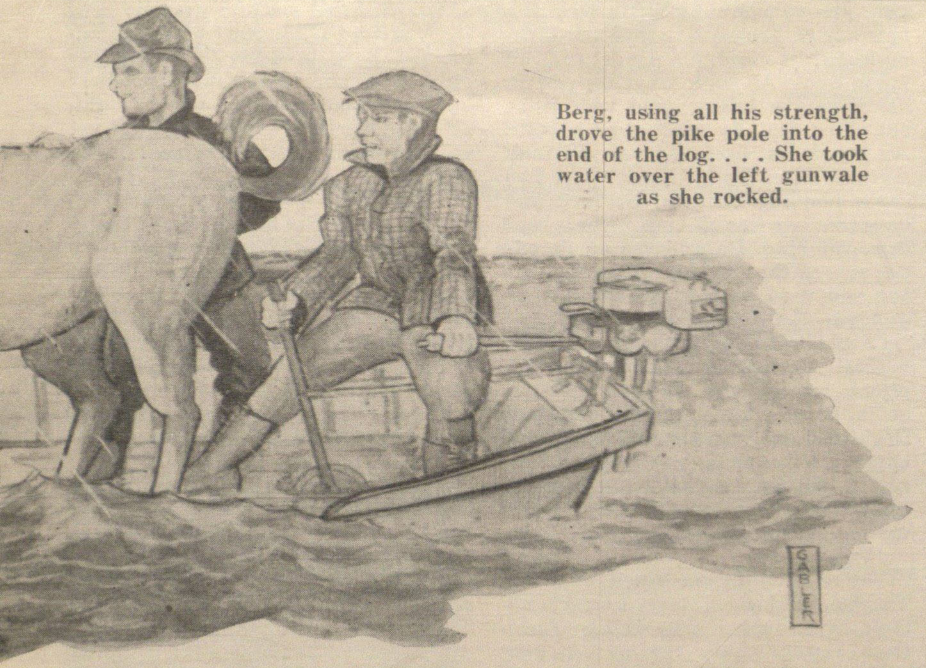
Horses? How would one take horses into this inaccessible country? Who would dream of transporting a horse up a swift and treacherous river in a small boat?

"Impossible!" was the cry of all concerned—except McQuillan. If horses was the solution to the problem, then horses it would be! A fortune of gold might be at stake! He would get them up the river, some way. However, had he known the experience in store for him he, too, would no doubt have been loath to attempt the feat.

WALTER C. BLANTON, president of the corporation, a veteran at the mining game, was detailed to make a trip to Stewart, B. C., to purchase two horses from Jack Rainey, a packer. Blanton knew of just the two horses most suitable. He had worked with them across glaciers and on hazardous trails to and from the Porter-Idaho mine near Stewart. They were horses long experienced in the ways of the woods and trail.

The animals, after having been purchased, spent part of last winter and all last spring awaiting favorable weather on the Bishop ranch at the mouth of the Unuk. Then, before they could be transported up the river, plans were changed. Blanton became air-minded. . . .

We have watched the gradual dethronement of Old Dobbin. First the automobile crowded him off the road, then machinery off the farm. The mountain fastness was one of his last empires. Now the airplane was taking his place here in moving mining machinery!



Berg, using all his strength, drove the pike pole into the end of the log. . . . She took water over the left gunwale as she rocked.

The company decided to employ airplanes to transport their supplies to the Unuk mining property. Food, machinery, and equipment, properly packed and wrapped so as to absorb part of the shock of the fall from the air, could be dropped in snow banks and on the alder slopes near the prospect. Some loss would occur through breakage, but, even so, the time saved would warrant the expense.

The horses would not be needed by the Blanton-McQuillan company, but the Premier Gold Mining Company, working farther up the trail at the head of the river, wanted them badly if they could be delivered at the boundary. They were sold with this stipulation. McQuillan offered to "carry on."

Here, with the advent of summer, our story begins. A fact story that records one of the most unusual feats ever attempted in the development of mineral resources.

* * *

"HOWARYA, Tommy!" came the cheerful greeting from the shore as Tommy McQuillan jumped from his shallow river boat to the float in front of the Bishop homestead at the mouth of the Unuk.

It was Preston Bishop. He grasped the painter of McQuillan's boat and made it fast to a cleat.

"Come for your horses, I suppose."

"Yep," returned Tommy. "Sold them to the Premier, got to deliver 'em at the boundary."

Tommy handed his pack to Harold Berg, who had accompanied him on his fifty-six mile voyage from the Premier's Unuk property, up the river.

Bishop immediately asked about the change in plans, and once seated inside the Bishop log cabin, he related the story. "You see, time's short and we want to get as much done as possible this season, before everything freezes up again. So we decided to fly our stuff in."

"But you're still going to take them horses up the river," interrupted Bishop.

"Right," agreed Tommy. "And that's not all. I'm expecting an engineer by the name of Don Cook and Ross Steele and his son, June. They're coming from Ketchikan and should be here any day now. And you're going to help us until they arrive."

"When do we start?"

"Start giving the horses their first lessons in riding river boats tomorrow."

TOMMY filled his pipe and stepped out into the darkness. It was late July and the valley of the Unuk was arrayed in her loveliest. A million stars twinkled down through the spires of stately spruce and hemlock. All was still save for the cry of a night bird and the rustle of leaves in the alders as the evening breeze stirred them gently.

Tommy carefully rechecked his plans. Well he knew that one slip-up on the river meant disaster, possibly death. The river seemed to take a Satanic joy in exacting its toll. The books of man recorded that the lives of ten men had been taken by the Unuk and these records did not go back very far. If a man entered the grasp of the silt-laden river, it was only a matter of moments till his clothes, weighted with entering silt, pulled him down beneath as surely and inexorably as though some devil had reached up with a clutching hand.

At length, Tommy drew on his pipe with a decisive air. Yes, everything should turn out all right unless some unforeseen obstacle presented itself.

The following morning, breakfast over, the three men started working on their transportation problem.

Berg, a rugged Norwegian, loaned by the Premier people to help transport the horses to the boundary, had his misgivings. "Tommy," he queried, "did Ay hear you said that ve got to train de horses fort and back, and fort and back in da boat so dat dey dam well know how to get in and out before ve start oop da river?"

"These horses," explained Tommy, "know a lot more than some humans I've been associated with. They'll understand what we expect of them in a few lessons."

Hours and hours of patience were required in teaching the heavy horses the proper method of boarding the light-weight river boat. Tommy would carefully lead a horse to the side of the boat, slowly lift one front hoof, then gently place it over the gunwale and lower it carefully to the floor of the boat. When Tommy pulled on the halter rope the horse would follow with his other feet and finally grasp the idea. The outboard motor was started to get the horse accustomed to the noise.

After numerous rehearsals for both horses, Tommy was satisfied that his cumbersome cargo was ready for the trip. "We leave in the morning." He gave his instructions before retiring. "Should be able to make it as far as Clearwater Creek before night."

SOME thirty years ago, during the days of the earliest mining activity on the Unuk, the Unuk River Mining and Dredging Company, known as "The Daily Interests," built a wagon road along the river at a cost of over two hundred twenty thousand dollars in order to provide easy transportation to its gold claims.

The Daily claims were soon abandoned. Nature began to reclaim the road, but some portions are still in evidence. Tommy chose to follow the Daily road on foot as far as possible.

After leaving the Bishop ranch the next morning, the horses were waded across the slough to the bank opposite the ranch. Here the old Daily road has its start. The animals were walked along the road only a short distance before it became necessary to teach them another maneuver. The horses must be made to swim across the slough to easier going on the opposite shore.

A stout line was tied to the halter and the line was taken across the slough in the river boat. The horses were then directed to cross by pulling on the rope. This process was repeated several times the first day before Clearwater Creek, a distance of only four miles from the start, was reached that night. They considered it a good day's work at that.

The supplies were put ashore, the horses staked out for the night. Tommy and Bishop prepared for their trip back to the ranch. It was likely that the men from Ketchikan would be there and they would be needed to help on the rest of the trip.

Taking his rifle and leaning it against a tree, Tommy turned to the

Norwegian, gathering wood for his camp. "I'll leave my rifle here with you, Berg, and we'll see you in the morning." With this parting, he climbed aboard and the small boat was headed down the slough.

After watching the boat disappear around a bend, Berg busied himself in preparations for the night. He started to cook the evening meal. He was hungry. At the same time, he thought of his horses and felt that they, too, would no doubt enjoy a meal. "Two damn goot horses, you bat my life," he said as he turned toward the two sacks of oats. . . .

What happened then had best be told by Berg, himself. He expressed himself forcibly to Tommy and Bishop when they returned the next day.

THE Ketchikan party was not at the ranch. It was late when Tommy decided not to wait any longer. He and Bishop got in the boat and, after a couple of jerks on the motor cord, the engine responded, pushing the blunt nose of the vessel down the slough.

This time Tommy chose to go by a different route—not up the slough, but by the main river. It would bring them to a point above where they had left Berg. They could save time by drifting back down the slough from the main stream.

They were a mile-and-a-half up river from the camp of the night before when they heard a shout from the shore. It was Berg, far from the spot they had left him! There was one big reason why he and the horses had not gone farther up the slough—they were smack up against a perpendicular stone cliff!

Berg was walking up and down the short beach, his fingers stroking his heavy blond hair. His face was white as chalk as he grasped the bow of the boat when it beached.

"What's wrong?" asked Tommy, glancing about in alarm. Horses and equipment were apparently safe.

"Wrong? Wrong!" he exclaimed, "dar's plen-tee wrong! Ay tall you—da whole night lang Ay don't get vun vink! Dis vas vun hell uf a place to leafe me and dem horses!"

"Well, what is the matter? Too many mosquitoes?"

"Mosquitoes, hell!" shouted Berg. "Bars—grizz-ily bars—all around of me on ev-ery side. Day vas in front and back and over har and over dar. Ay na-ver na-ver in all my life saw dem so thick, ya!"

Tommy and Bishop burst out in a laugh.

"Laugh, you damn id-jots, laugh, but you don't tank it so damn fun-ny if you vas har. Ay count four-teen and, py golly, if Ay do not tank at day vas hafing a con-vention or someting. Ven it start-ed to get light mit day dan day go avay, and you can bat you my life ve move avay, also, too. Ya, you bat Ay do not stay dar, no more!"

"Well, why didn't you use the gun I left with you?" laughed Tommy.

The Norwegian turned from chalk to scarlet.

"Ya, shure, vy don't Ay yuse da gun, ya—vy don't Ay?" He was now half angry. "So soon as you and Bishup leafe last night and Ay got my fire going goot, Ay tank maybe, perhaps, da horses be hungry and vant some oat. Yust den Ay start over to vare Ay put de oat sack and vat you tank Ay see, dan? Py golly, dar vas two coobs play-ing on dem dar sack and da mama bar was sit-ting down behind dem, vatching. Da gun vas on da odder side of the old lady. Py golly, mabee you vood vant to go and get da gun, ya—but not me, you bat my life!

"Right avay, Ay tank, py golly, da horses! Ay tank maybe sure day go plumb cra-zy, ya! Ay turn around, quick, but dar vas noth-ing doing, no! Day stood dar just like not-thing ever happen. Ay tank day vas not half so scared like Ay vas. Dat's vun ting Ay can-not fig-yure out—vy dem horses vas not scared of dem bars!"

"That's easy," explained Tommy. "They're used to the smell of bear. They've worked in bear country all their lives. Jack Rainey bought them from George Ball, the packer and guide at Telegraph Creek. Lots of bear up there."

"Ya, shure. Ay am yoost to bar, just like dem, but Ay do not like to hav an ar-my of dem cum to live vid me, no! Most all my life Ay live in bar countree, but last night var da furst-est tam Ay ev-ver sit oop all night vid two fire going vile two coobs playing and dar whole fam-ilee vid dar aunts and oonkles walking around me. Ay cer-tainly do not like it."

"Come on, let's get goin'." Tommy fastened an end of the long rope to the halter of Old Baldy, the gray mare. "We can make it as far as Six Mile Bluff today, if nothing happens."

"That is, if Berg doesn't run into any more 'bars'," laughed Bishop.

With a frown, Berg coiled the rest of the long halter rope and tossed it into the boat.

ONCE across, the rope was pulled and the mare was led into the water and made to swim.

This time, after emerging from the water and shaking herself like a dog, Old Baldy turned and glanced across the slough. Before Berg had time to untie the rope and take it across to the other horse, the mare whinnied to her companion.

Without hesitation, the horse on the opposite shore entered the water of his own accord and swam across. Here was new evidence of the unusual sagacity of the horses! They immediately won more admiration from all three men.

The horses were walked along the edge of the slough for a mile until a second crossing was necessary. Two of the men crossed the slough in the boat while the other remained with the horses. This time they abandoned the use of the rope altogether. At a simple, "Go long!" and a friendly slap on the rump, Old Baldy swam the slough to the two men on the other side. Then she whinnied across to her partner and the second horse again swam across. This simplified matters greatly.

"What did I tell you?" Tommy addressed Berg proudly, "Didn't I say they knew more than some humans?"

"Py golly, day are smart, all right, all right. Ay hope day don't forgot vot ve learn dem ven ve put dem in da boat."

"There'll be no more swimmin' 'em after we leave Six Mile Bluff." Tommy turned to Berg. "There's a chance we may have to go to Ketchikan if Don Cook and the Steeles haven't arrived at the ranch. Bishop and I will go down river now, so you had better pitch camp and stay here for a few days if we don't return in the morning."

Tommy paused. The Norwegian had a worried look on his face and was nervously stroking his bearded chin.

Tommy surmised what was going through Berg's mind. He chuckled. "Don't need to worry about bears here, Berg," he encouraged. "It was my fault that you got into that jam last night. I should have known better than to leave you on Clearwater Creek when there's so many salmon in the stream. I might have known there would be bear feeding. You'll be all right here."

In the boat, Tommy and Bishop waved to Berg on the river bank. The rifle was tightly clenched in the crook of an arm. "Bet he won't get ten feet away from that gun, from now on," laughed Bishop.

UPON reaching the Bishop ranch, Tommy found a message, which had been broadcast from Ketchikan radio station KGBU, waiting for him. It requested that he come to town at once.

After getting supplies and the engineer and the Steeles in town, they returned to the Unuk. After dinner at the Bishop ranch they observed something they knew would mean more trouble for Berg. Tommy stepped outside and cast a worried eye at the sky. Dark clouds were billowing above the tree tops. A brisk breeze was blowing, exposing the under side of the alder leaves.

Presently, a distant rumble reached his ear. Thunder! Then a flash, followed by another rumble. Storm in the upper country, he mused, shaking his head. Yes, it is moving down the valley!

Calling his men, Tommy directed that the supplies be stored in a sheltered place. Then came the storm! Blinding flashes of lightning. Deafening thunder!

Tommy glanced through a cabin window at the drenching downpour with dismay. Sheets of water, driven by a heavy gale, lashed against the glass.

"That's a tough break, Tommy," said Bishop, handing him a cup of coffee. "Might last a week, too."

No one knew better than Tommy the undependability of Southeastern Alaska weather. Now the river would rise, making it more difficult to ne-

—Please turn to page 20

NATURE'S PINCUSHION

(Continued from page 12)

Though he travels both day and night, Porky seems to prefer the late evening and early morning twilight. Just at dusk one evening, I drove from Moose Pass to Hope on Turnagain Arm, a distance of forty-six miles, and observed seventy-four of these animals on the trip. Early morning drives produced almost as many. Likewise, I have encountered a roaming Prickle-Cub on many occasions in the dead of night. Although he is found in practically all timbered regions of Alaska, the porcupine density has been reduced to almost nothing in many localities, nearly always at the hand of man.

Other enemies consist of forest fires and the insidious tapeworm. Wolverines practically live on porcupine when available, while lynx and wolves account for a few. Rumors are occasionally heard of a coyote becoming adept in turning the Porky on its back to expose the vulnerable underparts, but such instances are rare. No positive information is at hand to show the porcupine's span of life, but by the common rule of five times the period of growth he should last for about ten years—barring accidents.

In that time he can destroy a lot of trees. This is at the base of his persecution by man. In Alaska, he prefers to dine on hemlock, often spending days in one tree eating all within reach. Cottonwoods, aspens and spruce are not exempt. His diet also includes about everything common to a vegetarian. Water lilies and other aquatic plants likewise go into his quill manufacturing plant.

ON THE credit side of the ledger, however, we find at least one all-redeeming feature in the presence of porcupines. His utter stupidity makes him a readily obtainable source of food to a starving man and this fact has been the cause of protective legislation in a great many states. Further than that, his meat is greatly relished by many tribal natives and a few whites. My own experiments in this line would place him somewhat on the doubtful list, but every man to his taste. A few years ago the quills, lest we forget them, were extensively used by the Crow Indians in the manufacture of combs and ornamental trappings.

Porky's marriage customs, always a source of conjecture at any campfire, are not very well known. I observed a young Quiller near Eagle, Alaska, in late August and one nearly the same age and size in December, near Juneau. Such facts and his general make-up leave us in doubt as to how and when he breeds.

The generally conceded mating season is in late fall, but so far as I can determine the gestation period is unknown, which seems strange when one considers the wide range of these animals and the ease with which they may be approached. Ordinarily, one offspring is the rule and, according to most naturalists, it is born in the early spring.

The nest is built in a rocky den, under a protruding ledge, or sometimes under a hollow stump. Unlike the fortunate members of the bear family, Porky is obliged to stir around all winter in quest of a living. His vocal accomplishments consist of a varied chatter or odd-pitched moan, whichever seems appropriate to the occasion.

If he is forced to it, Porky can swim, or rather float on his air-filled quills while he paddles along.

Ordinarily unsociable and non-gregarious, the porcupine evidently leads a solitary life, always maintaining a poker face. Wherever several of these quadrupeds are congregated it is a sure sign that attractive food, rather than a desire for companionship, has brought them together. It has been said that the Quiller is almost impossible to tame, but I know of a young one that made a rather affectionate pet. He would crawl up to my father's shoulder to partake of a morsel of carrot and seemed to thoroughly enjoy the performance. One day he disappeared. Upon returning some two weeks later, the Porky stoically set about retrieving a bite to eat in the same manner as if the interval had been only a few minutes.

Because of his tree destruction, for the protection of dogs, and for use as fox feed, many a Quiller has been cheated of his allotted ten years. Add to this his many deficiencies, tapeworms and forest fires, and it is a wonder that he can still exist in the scheme of nature. However, the porcupine will probably always be with us and there's a very pointed reason—in fact thirty thousand of them!

HORSE POWER FOR UNUK GOLD

(Continued from page 16)

gotiate. He thought of Berg and the horses at Six Mile Bluff. Berg was equipped with a sleeping bag and a waterproof fly. Even so in a storm like this, it would be mighty disagreeable.

For two days the downpour continued. Then, on the evening of the second day, the wind subsided and the rain abated into a slow drizzle. If, thought Tommy, conditions were at all favorable in the morning, they would chance a trip up to Berg and the horses.

The Storm Gods smiled, and on the next morning they bid the Bishop ranch farewell.

This river navigation in a small boat was a new experience for Don Cook and the Steeles. The swift and now swollen waters of the Unuk provided them with several thrills before Six Mile Bluff was reached.

And there, on the river bank, was Berg! A more bedraggled, forlorn person cannot be imagined. He looked for all the world like a sick rooster. Five days had he spent in solitude with the horses, awaiting Tommy's return. He was too glad to see his friends to complain, but he was anxious to get going again.

After a hasty introduction of Berg to the new members of the party, Tommy set about to prepare for one of the greatest undertakings of his life.

It was time to load horses and supplies on the boat for the long, dangerous stretch ahead. Uneasy glances were exchanged by the others as Tommy led Old Baldy to the boat. Even the mare seemed to sense the gravity of the situation.

SLOWLY, Old Baldy raised one foot and placed it gently on the floor of the boat, then the other front foot. She hesitated a moment as the boat listed slightly, then, as if to say, "Well, here goes," she entered the boat, bracing her feet apart to maintain her balance.

"Good girl," commended Tommy, giving her a friendly pat on the neck as the mare timidly nosed his cuff.

"All right," said Tommy, calmly, "Ross, you remain here with the other horse and the rest of you come with me."

The motor was started and Tommy swung the bow slowly into the turbulent stream. Then, "Hang on to Baldy's halter, Cook, and talk to her. She's pretty nervous."

Tommy scanned the river with a cautious eye. It was wide and swift. The storm had flooded the river to a dangerous height. The water was muddy and he could not see scores of rocks, formerly in sight, now barely submerged by the flood waters. Fearing that he might crash, he swung the boat slowly toward mid-channel.

A shudder ran up Tommy's back as he sized up the situation. A twenty-eight foot boat, he mused, four men and the supplies . . . a horse . . . and two miles to go before I can put the horse ashore. . . . If she will only keep her head everything will be all right.

This seemed worse than tight-rope walking, trying to balance such a load in a boat which drew hardly four inches of water; the horse towering six feet above the swirling river!

TOMMY stood in the stern, his hand firmly grasping the tiller. He was listening to the rhythmic hum of the powerful twenty-two horsepower Johnson. He contemplated what the result might be if the motor failed. They would certainly be swept down to disaster, possibly death. The motor was in good condition, though—he had seen to that.

He was startled from his musings by a shout from the bow. "Look out, Tommy! A sweeper!" For a split second he was almost petrified with the danger ahead. Cold perspiration broke from his forehead.

"Ya, har, quick, swing her, swing her!" shouted Berg, excitedly, as he brought the pike pole into action.

There, not twenty-five feet ahead, directly in their path, was a large log, thirty feet in length. It was sweeping broadside toward them in the powerful current. Many thoughts raced

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bottle, using due care that our shooting endangers no innocent pilgrim.

Should there ever be a closed season on bottles and tin cans we can then very profitably construct or find already constructed some natural range providing all the requirements for the safety of the aforementioned pilgrim, put up a snooty target stamped "Standard American 20-yard Pistol Target" and see what rotten shots we really are. About this time we shall congratulate ourselves that the hand-gun man is a solitary bird.

HORSE POWER FOR UNUK GOLD

(Continued from page 20)

through Tommy's mind in the remaining seconds.

If he thrust the tiller hard over and swung the boat sharply the horse would surely lose her balance. Little chance for her to maneuver. They would we swamped!

He must act quickly. Tommy had but one choice. He would have to take it. In a flash, he thrust the tiller over in a wild effort to miss the battering ram. The frail little boat rolled as Baldy's weight shifted. Water poured over the gunwale. "We're lost!" screamed Steele.

Just then, Berg, using all his strength, drove the pike pole into the end of the log and forced the boat over to the other side. She took water over the left gunwale as she rocked.

There was a sickening sound as the log grazed along the side. Not a word was spoken. With surprising agility, Old Baldy maneuvered her feet to keep the balance. Her years of experience in packing heavy loads across slippery glaciers saved the party from a disasterous end.

Tommy, mopping the perspiration from his brow, finally addressed Berg in the bow. "Any of the supplies get wet?"

"Not a ting but a can of gas-oline," came the reply.

Tommy had hardly regained his composure before he sighted a large snag floating down directly in their course. Cautiously, he turned to avoid it, and heaved a sigh of relief as the snag swept past.

"That's a welcome sight," exclaimed Tommy as they rounded a bend in the river and approached the spot where he planned to put the horse and supplies ashore.

Leaving June Steele and Don Cook ashore with Old Baldy, Tommy and Berg returned for the other horse. Although not as thrilling as their other trip, there were many anxious moments during the second. They dodged more sweepers and picked their way cautiously along the winding course.

Two miles had been accomplished that day, making a total of eight miles from the ranch. The next sixteen miles were the most difficult. Tommy could think of no one he would be more glad to see than Sam Kirkpatrick at the boundary. Sam would take charge of the horses for the Premier people and Tommy and his party would accompany him along the trail the rest of the way.

Day after day they struggled on, walking the horses along the bank where possible and transporting them in the boat when necessary. It was a slow, grueling task.

On the seventh day, they reached the International boundary. With the greatest of pleasure, they turned the horses over to Kirkpatrick. Only one more stretch remained—the twelve-mile trip along the Canadian trail to the place it branched off toward the Premier property. That would be comparatively easy, even though the trail was not wide. It was simply a matter of walking ahead, the horses, carrying the packs, would follow. After that, Tommy and his party would proceed without the horses twelve miles farther, to the Unuk River Placer Gold Company's holdings.

ONE more apparent obstacle blocked the path of the horses, however. It was a seventy-five foot bridge, intended for human travel only, sixty feet above the river. It was constructed of two small logs, barely sixteen inches through. The tops of the stringers had been adzed off, forming a very springy walk only thirty-two inches wide. It had no railing and presented a dizzy aspect to even the engineer and the Steeles.

"How are you going to get them over that, Sam?" inquired Tommy of Kirkpatrick. Even Tommy was dubious about the horses' ability to do

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left "stagnant" ice that melted there without moving. So, since there was no ice erosion to scatter gold gravels, they remained in canyons thus favored, while most outlying districts were reduced to low grade deposits in places where they exist at all.

Whether similarly protected or reconcentrated, some places outside the Yentna district show promise: parts of the Kichatna and its branch creek the Nakochna; Independence Creek, which comes into Yentna River below the forks, where gold gravels exist that might be dredgable; and the head of Martin Creek, east of Peters Hills, where coarse gold was reported but little prospecting was done till lately. Also, the river bars on Lake Creek and the lower Kahiltna carry gold and some platinum which it might be possible to work by modern methods at a profit.

The Skwentna River above Portage Creek was unknown and unexplored till the U. S. Geological Survey went in, in 1926. It is navigable by small power boats to about seven miles above its junction with the Yentna, then by outboard-powered skiffs to Happy Creek, but above this point pack stock afford the only feasible means of travel. A flat, timbered lowland plain, dotted with swamps, extends nearly to Portage Creek, but above it the main river rushes down a steep gradient through narrow, high-walled canyons on the east slopes of the Alaska Range.

It is a wild, rugged region of snow peaks, glaciers and highwater summer streams, with severe cold, blizzards and deep snow in winter. But the creek bottoms are well grassed and timbered and, though game and trout are not plentiful, there are bear, wolf, caribou, bighorn, rabbit, ptarmigan and fur animals in limited amount. There is much unfavorable glacial drift nearly up to Happy Creek. Above that, especially from Hayes Creek onward, the rock formation is promising and but little prospected.

On the upper river, sedimentary shales, slates and argillites make a contact with granites coming in from the Alaska Range; a condition very favorable for mineral deposits which should attract prospectors even though Hayes Creek does lie about a hundred miles from Cook Inlet. As an added attraction, the formation extends through a gap in the Alaska Range, known as Ptarmigan Pass, to the headwaters of the south fork of the Kuskokwim River, where coarse gold has been reported in the gravels of a branch stream called "Styx Creek." Prospectors hardy enough to winter there might find summer exploration very profitable.

The West Fork of the Chulitna is an area of altered sedimentary rocks contacted by intrusive dykes and upthrusts of andesite and porphoritic quartz diorites. It is all much sheared, folded and faulted, but sulphide minerals are widely distributed throughout. Many deposits bearing gold, silver, copper, galena and zinc exist. Though well prospected, vein exposures are poor and often buried under brush and slide material. But the character of lodes discovered, though of rather low grade, seems to indicate that values may persist to more than average depths. Yet this area is remote and, to be profitable, ore bodies must be rich.

The Talkeetna Mountains are rugged, remote and lack trails, though it is all an igneous-sedimentary formation which has much promise, particularly the northwestern slopes overlooking Valdez Creek and adjacent streams —also the Iron Creek country, to the southeast. Large gold bearing dykes exist on the upper Talkeetna River and deposits of massive bornite, with free gold and platinum are found on the Kashwitna farther south.

Valdez Creek, about forty miles airline from the Alaska Railroad, has had much activity in both placer and lode mining since 1925. Placers on the main creek and branches from the south have produced for several years, with valuable strikes of quartz gold made recently.

Summarizing, we may say: favorable prospecting districts in the Susitna drainage area seem to include Valdez Creek and the Talkeetna Mountains, with promise also in the Skwentna-Styx Creek region.

HORSE POWER FOR UNUK GOLD

(Continued from page 22)

an act of "tight-log" walking like that.

"Don't worry about that," returned Sam. "Show me a horse that has worked for Jack Rainey and I'll show you a horse with legs trained for any footing."

"Now, look here, Sam," pleaded Tommy, "We've risked our lives and gone through hell and high water to get these hay-burners this far. Don't let's lose them, now. Why not lead them down the hill and ford 'em."

"Rats," returned Sam, disgustedly. "That'd take three hours or more."

After removing the packs, Sam led the horses, one at a time, across the swaying bridge. These were breath-taking moments for all, apparently, except Sam.

It was with great relief that Tommy, Cook and the two Steeles bid adieu to Berg, Kirkpatrick and the two horses.

As they stood and watched the two men and the horses trudging on to the Premier property, they saw Old Baldy stop. She half turned in the trail and peered over her shoulder. Raising her head into the air, she issued a loud whinny, as if to say, "It was a grand trip, boys! Goodbye!"

THE WATER TRAIL

(Continued from page 11)

trict attorney has his eyes on bigger offices in the coming elections."

"But the boy is innocent," protested Lon.

"Now, just a minute. Let me finish. I'm inclined to think that he's telling the truth, but there is only one man on the cutter that says he thinks there were two boats. That isn't enough." The attorney's hand tightened on Lon's shoulder.

"If Tug Moran framed your brother, and the whole thing was not just an accidental meeting with the cutter, he has certainly framed him well. He

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JUNEAU ROOMING HOUSE—Over Juneau Billiard Parlors. Quiet, comfortable rooms. Baggage stored while you are out of town. Rates 50c. per day and up. Mrs. J. H. Ahlers, Mgr.

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FOR RENT—Six-room completely furnished house; electric range and heating plant; economical on fuel. Call at Empire or telephone 205.

FOR RENT—4-room house, completely furnished. Phone 429.

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211 Seward St.
Telephone 441. P. O. Box 251

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NOTICE OF CHANGE OF NAME OF VESSEL
Notice is hereby given that the Commissioner of navigation has granted authority for the change in the name of the Ga. s. JA-KA-DAN, official number 216665, to NUGGET. Wm. C. Wright, owner. adv

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No matter what make of boiler or oven, I can build it right for you, because I specialize in this particular line.
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HILLSIDE BATH HOUSE—Turkish, Needle, Steam, Shower and tub baths. Dry and steam heat. William Lott, expert masseuse will be in attendance on Wednesday and Saturday of each week. 212 Front St., Phone 163.

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Tub and shower baths. Tobacco, candies, soft drinks in connection. Near City Dock. 329 Front St. Phone 433.
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WANTED TO BUY—High-backed sulky. Phone 1512.

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WANTED—Musicians. All instruments. Call Carl H. Erickson, Phone 15. Douglas.

WANTED—Maid for general house work. Apply Goldstein's Emporium.

WANTED—Man to take charge of lath mill. Apply Juneau Lumber Mills.

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LOST—Wristwatch in leather case. Finder please return to Nelson's Stationery Store. Liberal reward.

LOST—One belt axe on Mendenhall Road. Return to Empire C-174.

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MAN IN THE MOON PROFESSOR'S TARGET IN TEST OF ROCKETS

WASHINGTON, May 13.—Test of the new rocket apparatus designed by Professor R H Goddard, to reach altitudes far above the earth's air envelope and, as a vague possibility, even to the moon will be made late in July at Worcester, Mass., the National Geographic Society announced.

MEETING POSTPONED

The regular monthly meeting of the Juneau Woman's Club has been postponed to Wednesday, May 19.

Fraternal Societies
OF
Gastineau Channel

B. P. O. ELKS
Meeting Wednesday Evening at 8:00 o'clock Elks' Hall.
J. A. SNOW, Exalted Ruler
JOHN J. DAVIS, Secretary

Co-Ordinate Bodies Scottish Rite
May 7 — Regular business meeting all bodies.
May 21—Lodge of Perfection. Degree work.

I. O. O. F.
SILVER BOW LODGE NO. 2.
Meets every Thursday evening at 7:30, Odd Fellows' Hall 2nd and Franklin Sts. Earl E. Smith, Sec'y.; E. M. Polley, Noble Grand. Visiting I.O.O.F. welcome.

MOUNT JUNEAU LODGE NO. 147, F. & A. M.
Stated Communication
Second and Fourth Mondays of each Month, in Odd Fellows Hall, beginning at 7:30 o'clock.
J. W. McDANIELS, Master.
H. E. BROWN, Secretary.

Order of the
EASTERN STAR
Second and Fourth Tuesdays of each month.
At 8 o'clock, I. O. O. F. Hall
CLEMENTINE WAHLGREEN, W. M.
LOUIS E. McCOY, Sec'y.

KNIGHTS OF COLUMBUS
Archbishop Seghers Council No. 1760. Meetings second and last Mondays at 7:30 p. m. Transient Brothers urged to attend Council Chambers, Fifth St. Barney A. Roselle, G. K.; James F. Hurley, Sec'y.

PERSEVERANCE REBEKAH LODGE NO. 2-A, I. O. O. F.
Meets 1st. and 3d. Tues. evenings in Odd Fellows' Hall, 8 o'clock. Visiting members always welcome. Alice Laughlin, Sec'y.; Edna E. Polly, N. G.

INFORMAL INVITATIONAL DANCE
Under Auspices Nobles Mystic Shrine of the S. E. A. Shrine Club on THIRD THURSDAY OF EVERY MONTH IN ELKS HALL at 9 p. m. Each Noble may invite as many guests (Masons or non-Masons) as desired. Present invitation at door. The Fez MUST be worn.

AMERICAN LEGION
Alford John Bradford Post No. 4 Juneau, Alaska.
Regular meetings on third Thursday of each month, at 8 p. m. in Elks' Lodge Room. Dr. H. C. DeVighne, Post Commander, Phone 104; George E. Mann, Secretary Phone 196.

LOYAL ORDER OF MOOSE, Juneau Lodge 700
Meets every Friday night, 8 o'clock, Moose Hall. S. Wallstedt, Dictator; R. H. Stevens, Secretary.

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UP-TO-DATE Millinery work done. New hats made out of old ones. Save money by seeing Mrs. Schwarzenberg, Douglas. Phone 452. adv

ALASKA NOTES

Mrs. Joseph McDonald of Ester Creek has received the news of the death of her brother, William Regan, at Seattle.

The Cordova Chamber of Commerce has endorsed the proposed Alaska Development Board.

William Thompson, pioneer resident of Cordova, died at that place recently. He is survived by a brother at Cedar Ridge, Mont., and a sister at Boise, Idaho. The funeral occurred at Cordova.

Eleven members were admitted to the Cordova Igloo of Pioneers in one night.

George R. Goshaw, formerly United States Deputy Marshal in the Third Division, who has been in the Nome country and the Alaska Interior buying furs for two years, recently left for New York. He made the trip overland from Nome.

A mail service has been established between Sulzer and Chomley A contract for the delivery of the mail has been awarded to E. J. Williams who carried the mail from Ketchikan to the portage at Sulzer, owner of the Rough Rider and the Taku II.

Salvage from the Libby, McNeil and Libby barge, Dashing Wave is being brought into Ketchikan. A large part of the cargo, consisting of machinery and cannery supplies, have been saved. The Dashing Wave was wrecked a few weeks ago bound from Seattle to Alaska.

P. L. Neil, Postoffice inspector, paid Postmaster J. F. Warder of Ketchikan, who has resigned, in order to accept the position of United States Commissioner at Ketchikan the compliment of saying: "You have the most efficient and accommodating office in the country and the department regrets losing such a competent executive who has handled the local situation so successfully."

The Petersburg City Council has elected L. J. Morrison City Clerk and Magistrate, C. C. Clausen City Treasurer, W. P. Mowes City Electrician and E. N. Ohmer Chief or the Fire Department.

Anton Eide, for the Road Commission, has started work on the road from Petersburg to Scow Bay.

Rev W. J. Maakestead, pastor of the Lutheran church at Petersburg, has left that place for Tacoma, where he will reside in the future.

Robert W. Kellen, old-timer of the Alaska Interior and father of Mrs. M. A. Schaeffer and O. W. Kellen, died hecently.

R. E. Small, of the Seatle firm of Kelly-Clark Company, who has returned to Seattle from a trip throughout the East, says the outlook is for a marked improvement in the salmon market. He predicts there will be little difficulty in selling the 1920 pack.

Ketchikan will appropriately observe Memorial Day, May 30. Among the features of the observance will be a parade in which the American Legion will join.

M. S. Dobbs has been elected school tax collector at Ketchikan, vice George Woodruff, who was called to Seattle to attend to his father's fur business on account of the illness of the latter.

Joe Ulmer of Ketchikan, who took a party consisting of H. A. Warner, Perry Warner and William Fortuny to the Unuk river and returned to Ketchikan, says the season is a month late at the Unuk. The Warner party is taking supplies and an outfit up the Unuk river for a party of engineers who will mark the international boundary at that place with monuments. They will take the outfit up the river in a poling boat and expect to be back at the mouth of the river to meet the engineers May 17th.

We are helping to bring down the high cost of living and still serving the same good meals. Alaska Grill. adv.

BRINGING UP FATHER
By McManus

STAN BISHOP—A TRUE SOURDOUGH

COMING TO ALASKA AND THE YES BAY HATCHERY

Stan: I told Mrs. Hoover that my biggest ambition was to go to Alaska. So she said, "Maybe we can help you, Stanley." So she told Mr. Hoover about it, he was still Secretary of Commerce at the time, and he arranged for me to come up on a Bureau of Fisheries boat.
[NOTE: ***It's hard to establish the chronology here, but Mr. Hoover was Secretary of Commerce until elected President in 1928. I'm assuming Stan first went to Alaska and the Yes Bay hatchery in 1928—he would have been about 16 years old then.*** BH]

So I was a "pull-punk." Local boys never got through rubbing that in. But I made my way through just as tough conditions as they did; I did more work than they did, too. So it was more joking than malicious, but they never let me forget that I was a "pull-punk." You got your job through pull. But I'll never forget them; I'll never forget Mrs. Hoover. I lost track of 'em after I was up here a few years, but I still remember the number of their house, 327 Laredo Street, I can always remember that.

Then I went back and went to school, finished high school. I had to take an extra year of high school because I was short one credit...took a whole year...

Don: Where was that, Stan?

Stan: California. I managed to graduate and after I graduated I came back here and went to work for the people who were running the hatchery [at] Yes Bay. It was up on Lake McDonald. It was a big operation. People don't realize the extent of the operations that went on here when we were a territory... Don: Is that a sockeye stream mainly? Stan: Sockeye, yes. We released about 40 million fish a year. At that time the sockeye run was just about wiped out in that part of the country. The Yes Bay run used to be a big prolific run and they just wiped the fish out, between their fish traps and everything. If it hadn't changed, we wouldn't have any fish today at all. Nobody was doing any conservation at all and the fish were deteriorating all the time. But the sockeye came back into Yes Bay after...thanks to the hatchery.

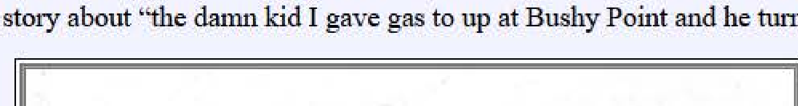
Yes Bay Hatchery Building ca 1932
on north shore of Lake MacDonald

But there would have been lots of improvements that we could of put in but when you're running a hatchery you have to comply with their regulations and everything, and we weren't allowed to protect the fish once we turned 'em loose in Lake McDonald, which we could have done. We could have protected them a lot more than we did.

[Stan's enthusiasm for Alaska and interest in the Unuk River area was evident in a letter written April 24, 1932 by Stan's boss, Alphonse Kemmerich, Superintendent of the Yes Bay fish hatchery from 1928 until its closing: *"Stanley Bishop returned from his trip of adventure to the Unuk River country. He left a day or so before we went to town. He returned yesterday. Got a wolf on his trip. I saw him at the cannery last night. He was all excited over his journey."*]

Stan: I got a story to tell about Sam Bartholomew, who ran the *Murre*, a Bureau of Fisheries patrol boat [when Alaska] was still a territory... I bought this boat from this guy in Seattle and he shipped it up here, and it had a Model T Ford engine in it, conversion, and I started out from town. Filled the tank, it had an automobile tank for gas. And I ran out of gas up at Bushy Point, and I didn't worry about it, I had a pole on there and I raised the pole and took a blanket and hung on it. And I was sailing along at a pretty good clip up toward Yes Bay and here this *Murre*, the patrol boat, came along. And he came to a stop. And he said, "Where you goin', kid?" And I said, "I'm on my way to Yes Bay." "Well," he says, "what are you sailing for?" I said, "Well, I've run out of gas." "Well," he says, "come on here to Bushy Point and we'll anchor up and give you some gas." So they did, they went and anchored up and while they were siphoning gas out of the tank, he says, "You go down and have lunch with the cook." That was the way they did things in those days, you know.

So I had a good meal and I got out of there with my pockets full of apples and oranges and stuff and they said, "Well, your tank is full and we gave you five gallons extra." And I thanked him and I got on my boat--I just had it tied up with one line at the bow--and they pushed the boat off and I went down and got the engine all ready and I started it up and I heard a lot of yelling and screaming and I ran out to the cockpit and here I was headed right square for the broadside of the Murre. And this Model T Conversion had this old transmission in it and when the oil was cold it dragged, there was no neutral to it. So my wheel was...the prop was turning around and here I was headed right for Murre! So I just threw myself against the tiller and I grazed right along the bulwarks on the Murre --that was how close it came--and I heard Sam yelling out, "You God-damned, crazy kid!" He says, "We give you gas and food and you try to ram us!" And I was too busy to pay much attention to it, but I got to Yes Bay. Sam came into town and told a story about "the damn kid I gave gas to up at Bushy Point and he turned around and tried to ram us!"



Yes Bay and Cannery ca. 1932

Stan: …When the new [Roosevelt] administration came in it became a different division. It was under Department of Commerce to start with, which had charge of the Bureau of Fisheries. All our fisheries were handled as a territory then, of course. Then when it changed over to Roosevelt's administration, they did away with the hatcheries up here. Closed 'em all down. And we were given a choice of going down to the states and getting into a sport-fish hatchery, or quitting...If we wanted to stay up here, we just lost our job. So I just told 'em I wasn't moving away from here.

* * * * * * * * *

STAN BISHOP—A TRUE SOURDOUGH

THE UNUK RIVER

An Alaska Dept. of Fish &Game; technician on the Unuk River in the Spring.

Photograph property of the Alaska Dept. of Fish & Game
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Louise: So that first winter at Yes Bay, did you all live in a cabin there?

Stan: Well, we stayed in this cabin and then the next spring I went up and visited the Unuk River. I bought an outboard, but it failed on me on the very first trip. I had a 17-foot dory and I rowed it from Yes Bay to the Unuk River.

Don: How did you like to row, standing up?
Stan: Standing up, it's the only way you can row for a heavy boat. It's the only way you can put full force on your oars. Especially a dory. It's got high sides on it and you can't sit in a dory, you can hardly reach the water with the oars if you're sitting on the seats. But by standing up your oars are sharper, down the sides; then you can put your legs into it, too. It's not coming all in your midsection.

Don: It's in your shoulders.
Stan: Yeah. So that's the only way to row a long distance and you can do that all day long. Sometimes your feet will get tired, but it's the only way to row a long distance. Some days I wouldn't make hardly any mileage at all and other days I could sail a little bit of the time. So it took me four days to get up there. And that winter Harvey Matney had moved into the Unuk, so he'd just started out, too. And he had quite an outfit. He moved all his floats and his donkey engine in there. He'd been logging down in back of Spacious Bay. But he was going to start a farm up there. He had everything figured out.

This topographic map shows the "Matney Ranch"
near the mouth of the Unuk River
and the "Bishop Ranch" just northwest on the Eulachon River.

Stan: And he persuaded me to come back up and stay with him that next winter. Which we did. I went back and we got the boat loaded with groceries and meanwhile I'd bought a little double-ender power boat from a guy in Seattle. And that was our sole means of transportation, besides my dory; 'course that dory was big enough I could load the whole family's belongings in it and tow it behind. It was a regular old-fashioned codfish dory. So we spent the next winter on the Unuk and I spent most of my time cutting wood.

Louise: Were you right there by Matney's place?
Stan: Up towards the rock there. Big whirlpool. You know I've seen ice come down there and pile up ten feet thick. Come down and hit the rocks there and slide up and fall back on top of itself, layer after layer of it, until it got eight- or ten-feet thick and then it would come over in a big crash and the whole thing would splinter up. And when there's a high water--which we went through two of 'em while we were there--the amount of action from the river against that bluff is just something you can't describe. Whole trees come down there and hit that bluff where the turn is, a whole tree with the roots might stand straight up and down and then fall over. We had 28 inches of water on our island which is farther up the slough there.

up the slough there.

In fact the water was so swift I couldn't take a chance on going out to our barn because I was afraid of getting swept off my feet. We lost a lot of equipment because we didn't have it up high enough. I had a farm tractor...the water covered part of the farm tractor.

Louise: I don't know how you survived a winter up there...
Stan: Well, from day to day, one day at a time. Like I say, I cut wood continuously with a crosscut saw. Everyday I cut at least two or three blocks and by late in the winter, the freezing weather, it was about a two-inch thick rind around every log. It was just like bone; you couldn't saw it, you had to chop it off. I'd chop a ring around, and then saw the rest of it with a crosscut saw. Then you burn about three times the amount; in fact, you had to burn one wood box full to dry out enough to burn one stove full. And we had wood in the oven all the time, trying to dry it out.

Don: Much wind, Stan?
Stan: Oh, just screams out of there. Coming down the river. It'd be out of the question to go, even if you could get out of there, it still would be out of the question. All you have to do is be down at Grant Creek and see it, where the wind is so hard, there's no waves; it just picks the water up and it's smooth, but the wind is blowing snow and spume level with the water. And whirlpools, just constant whirlpools. I never had any measurement for the wind, but I would guess it was blowing a steady 50 to 70 miles an hour all the time out in Burroughs Bay there.

Louise: But that winter you had your family there...that must have been difficult?
Stan: Yeah, my brother and sister and my mother, and we were constantly fighting off the winter. You'd go to sleep at night and in the morning you'd wake up with your bedclothes frozen to the wall. This little float house that Matney gave us to stay in wasn't built for that kind of weather at all. It had no insulation in it and the wind came right through the walls, through all the cracks. And wherever it found a crack your body heat would create condensation there and quite often your bedclothes would freeze solid to the wall. You'd have to get up and carefully pull them loose, so as not to tear the fabric. But all in all, it was quite an exasperating winter.

Louise: Well, you made it through that first winter on the river, what did you do then?
Stan: Then we took up the island, our island as a homestead.

Louise: Now, your father stayed in California?
Stan: He wasn't interested in Alaska at that time.

Louise: He DID come up, though...
Stan: Yes, we sent for him to come up. Mother told him she wasn't going back down there to California so he came up here.

Don: When you said you were farming, what were you farming, Stan?
Stan: Oh, we grew almost all the hardy vegetables. And when I took up my own place on the Ooligan,[Eulachon River] I had quite an extensive operation in there. I grew vegetables and brought 'em to town during the war. [World War II]

* * * * * * * * *

STAN BISHOP—A TRUE SOURDOUGH

PLACER GOLD MINING ON THE UNUK

Stan: I had a placer mine on Sulfirettes Creek, clear up [at] the head of it. Close to seventy miles from the mouth of the [Unuk] river.

Don: Did you get a lot of good ore out of there, good placer?
Stan: Well, I brought placer out for three years…. I just scratched the surface. But I sold my gold to Gus Pruell. It was all jewelry gold, all big heavy gold. And then Walt Blanton bought one batch that I brought down, $3800 worth in one bottle. The price of gold at the time was $27. Gus gave me a little bit of an edge because it was jewelry gold and he didn't have to do anything, except burnish it up a little bit. The strange thing about this gold was that most of it was black because it had been deposited in pyrite millions of years ago, and it had gotten black from the iron. And my first pan that I took and I found coarse gold in; I didn't know what I had. I could see these chunks of black stuff that hung back in the pan, and I picked a piece up and scratched it on the bottom of the rusty pan, and it was gold. But it was as black as coal.

Don: I've never heard of that!
Stan: But I put the gold in bottles and put baking soda in with it and after a week or ten days, it had eaten most of the black off the gold.

Don: It was just on the surface of the gold?
Stan: Well, where the gold was, which was down in bedrock, either on bedrock or in artificial bedrock, which would be any part of the pyrite formation where gold comes out, it usually lays on top of the pyrite because pyrite is heavy, too. It's almost pure iron, and the gold, a lot of times, is spread out on top of this pyrite bedrock, a false bedrock. So that's a whole story in itself.

Don: Is that close to where Duke Killbury had his mine?
Stan: Well, he took my location. Yeah, he jumped my claim...

Don: That old rascal!
Stan: I was sitting in my house over at Temsco, I used to own a house there where Temsco is now, and I heard the telephone ringing and I answered it and he says, "This is Duke." I said, "Duke who?" He said, "Duke Killbury. I'm sitting on your claim up on the Sulphide. And here it was in the dead of winter. I couldn't even believe him! I said, "Well, how can you do that?" He says, "Well, I've got a radio up here." He had a radio; he could reach Vancouver and have it rebroadcast up this way. So he called me to gloat over the fact that he had jumped my claim up there! That was unusual; I tell you, I could hardly believe it when he said where he was. He said, "I'm up on the Sulphide."

Don: Were you able to do anything about it,
Stan? Stan: No, I didn't.

* * * * * * * * *

STAN BISHOP—A TRUE SOURDOUGH

FREIGHTING ON THE UNUK

Stan: When I was developing the Ooligan, 'course I was doing other things at the same time...

Louise: That's what I was thinking...you were trapping and freighting...

Stan: When I first started freighting on the Unuk River with my big 30-foot river boat, I had an outboard which we thought was a big deal.

Don: Did that [boat] have the house forward? 60-footer, maybe?

Stan: Yes. We went over to Stewart and I bought two horses from … the old packer over there who had horses, he had around 20 horses, and he told me he'd give me two horses that were best suited for me. He said, "They're not young, they're old horses but they'll probably know more about packing than you'll ever learn."

Don: And did it work out that way?
Stan: Just exactly. These horses knew more about it than I did. To give you an illustration of it, after we built the trail we had logs across a lot of the little creek beds that we'd hewed the top down to maybe a 12-14-inch top. And one of these was a pretty high drop-off, if you fell off the log. And I decided my first trip up that I would cut a trail down for the horses and ford the creek and then come up the other side, instead of walking across this little log. So I left the horses standing up at the top and I went down and brushed out a trail, nice neat trail into the creek bed, and I heard something thumping up above. And I looked up and here old Mike was starting across this log, one foot ahead of the other, very carefully, and he couldn't put two feet together, he had to swing his legs out to come around his feet. And then old Dutch followed him and they made it perfect and here I was working myself to death to...(Lots of laughter) But that's a good example of it, 'cause a lot of times they would go places that I didn't think was proper for them.

I brought the horses out to Hyder and loaded 'em at Hyder. I walked 'em down the pedestrian float and put a couple boards up and they walked 'em on to the side of the boat, put one on each side of the gurry house, instead of having an open hold, he had kind of a little raised deck there and I put a horse on each side. And those old horses stood there as calm and collected as could be on that trip all the way down the Portland Canal and up...I took them off here at Ketchikan and walked them off of the boat and onto the float and down the float and up the pedestrian ramp at the machine shop there. That was a new slip there at the time and I figured it was perfectly safe.

And another thing the horses did, they didn't shake anything when they walked on it. They didn't have any cadence at all, they just put their foot out and would tamp it up and down a couple times and they'd move ahead a little bit, that's how they got by with so much that a normal horse would ruin, you know. You get a horse that has a cadence to their gait and they start to walk across something like that and before you know it the whole thing is shaking itself to pieces.

* * * * * * * * *

Pioneers of Southeast Alaska

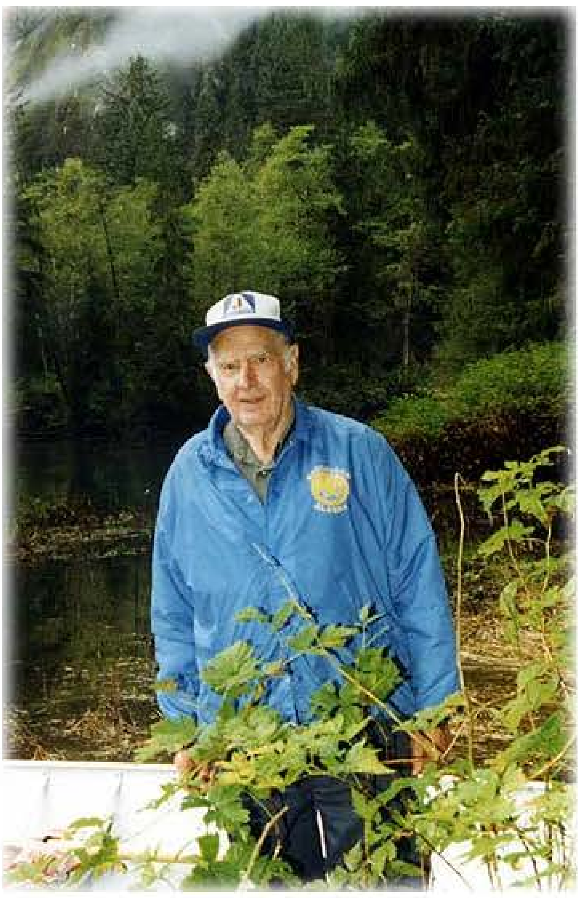
Bruce Johnstone

By Louise Brinck Harrington

August 17, 2006
Thursday PM

Ketchikan, Alaska - *In 1994 my husband and I bought an old classic yacht, the DUCHESS, and invited Bruce to accompany us on a trip around Revillagigedo Island. When he agreed to go, we stocked up on food and fuel, started off and I wrote the following story about the trip for The Alaskan Southeaster Magazine.*

The Man Who Hand-logged, Hunted, Trapped, Prospected and Became an Alaskan Pioneer



Bruce Johnstone on the Rudyerd River

White mist covers the mountains and settles along high granite ridges as the DUCHESS chugs her way into Rudyerd Bay. It is September and patches of devils club are turning yellow and orange, bright against an evergreen backdrop; cottonwoods shimmer like gold in the fall sunshine, and red alder leaves float into a rain-washed stream.

From the deck, Bruce Johnstone surveys the bay. The high granite cliffs look much the same as when he arrived as an 11-year old-boy in 1920 with his father, mother, two brothers and two sisters. Bruce was born in British Columbia, in a place called Deserted Bay. His father Charles Johnstone moved the family further and further into the wilderness, while his mother Dora, a former schoolteacher, taught her nine children to read and write in some of the most remote locations of British Columbia and Southeastern Alaska.

As the DUCHESS approaches the head of the bay, Bruce points to the grass-covered stump-filled river flats. "There used to be so many bear in there we didn't even bring our hunters in. It would be too easy, no challenge."

In former years Bruce was a bear hunter and big-game guide who learned to hunt here in Rudyerd Bay. As I stand beside him on the deck, spellbound by the beauty surrounding us, I encourage him to talk about this wild country that he knows better than anyone else.

He tells about his trap lines: the one that ran up Rudyerd River and the other up One-Eyed creek, which was named for Bruce's father who lost an eye to the thorny devils club branches that still grow along the bank.

He talks about his first encounter with a bear that got caught in his wolf trap: "And what I thought was a wolf turned out to be a grizzly cub. As I stood there trying to figure out how to shoot it, I realized the crows that had been all over had disappeared and the only sound was the rattle of the trap chain, the cub trying to get out. Then I heard another noise behind me. I turned around and looked up at a sow grizzly."

Bruce shot from the hip, then turned and ran until his lungs hurt so badly he had to stop. When he mustered up the courage to return to the trap, he found the sow slumped with a hole the size of his fist through her neck. That was the year Bruce turned 12.

He explains how his family lived in three different locations in Rudyerd Bay, the first near the mouth of the bay. Here the steep tree-studded cliffs provided good terrain for hand-logging but were prone to landslides, which made Charles Johnstone nervous. When a slide came down too close to the cabin, he moved the family to the river flats where the bay divides into its north and south arms. But another too-close-for-comfort slide forced them to move again, this time to the beach near Nooya Creek, where they lived for four years.

His face turns solemn as he gazes up the creek toward Nooya Lake, which he says is the most beautiful place in the world and where his late wife's ashes are buried. He pauses and then tells about Helen and how they married on March 1, 1955 and moved immediately into a small cabin at Clover Pass.

The night they moved in, the temperature dropped to below zero and the oil line to the cabin froze. Even inside the cabin all the food froze, as did a can of water right next to the stove.

The next day Bruce took the bus to town, bought a blow torch and thawed out the line. What a honeymoon!

As we leave Rudyerd the following day it is raining, hard and straight down, and the DUCHESS rolls from side to side as she enters Behm Canal. From the pilot house, Bruce points out to the lava-formed Eddystone Rock, which rises from the middle of the canal to a height of 237 feet and seems to dominate the entire area.
"The old Indians tell a story about that thing just drifting in here," he says, observing Eddystone intently. It is the final resting place of another relative, his younger sister Kate, who died in 1933 and spent much of her childhood in the area.

We tie up to a buoy at Ella Bay, where the Johnstone family built a sturdy log cabin in the fall of 1920. Ella Creek flows into the bay from the west about a quarter mile south of the old cabin site. One December night Bruce and his brothers Jud and Jack decided to hike up the three-mile creek to its headwaters.

"About three days before Christmas, it was," Bruce recounts with a twinkle in his eye," ten o'clock at night. At the top of the trail there's an overhanging cliff and we had a fire just inside the drip. We saw this thing walking along a game trail. He stopped, turned around and looked at us, and then walked off. He was dressed in an old buffalo jacket and shoe packs with rubber bottoms and leather tops. You could see the cliff right through him."

I have heard this story before and give him a skeptical look. "Go ahead, I dare you," he says. "Go up and get a picture of the French Ghost!"

Because the phantom wrote his name in charcoal, Jacques, on the back of the cliff, the Johnstone brothers dubbed him the "French Ghost." And Bruce swears the ghost was seen a few years later by a Crown-Zellerbach crew, in broad daylight.

"One loggers axe is still sticking in the tree," Bruce laughs.

Leaving Ella Bay, the DUCHESS heads north, up East Behm to Burroughs Bay. Though the rain has stopped, evening approaches by the time we arrive and tie up to a buoy near the mouth of the Unuk River. The mist drifts lower and lower, settling on the river in wispy strands.

In the early thirties, Bruce and his brother Jack prospected up the river, as far as the Canadian boundary and beyond. Bruce says it wasn't the gold so much as the chase, the thrill of the hunt. It was on a prospecting trip in 1935 that Bruce came face to face with "Old Groaner," a wounded grizzly who earned his name for haunting prospecting camps and making strange moaning sounds.

The old bruin had been groaning around for years, according to old prospectors, but never before shown himself to a human being. For some reason he decided to not only appear, but charge while Bruce was staking a notice on a claim!

Before Bruce could reach for his .405 Winchester, his dog, Slasher, attacked the bear, chewing and holding onto its hind foot. This gave Bruce time to grab the gun and fire. It took three shots to kill Old Groaner who crumpled at Bruce's feet! He turned out to be a giant bear with a skull measurement of 17 by 11 inches.

But in 1958, Bruce was not so lucky. One September morning while on a moose hunt, he took a shotgun and went out on the Unuk River flats to bag a few ducks for camp meat.

At first he did not even see the three hungry grizzlies lurking in the willow trees and brush. "It was one of those things that aren't supposed to happen," he explains. "But that year there were few berries and hardly any fish and the bear were starving to death.

"It was a big old boar, a sow and a two-year old cub. I thought I'd better kill the biggest one first, but just as I pulled the trigger, the female hit me. So instead of shooting the boar where I wanted to, I just shot his eyes out."

After Bruce wounded the boar, he finally managed to kill the female, but not before she "chewed me up pretty bad." A group of hunters from the lodge further up the river heard Bruce and the sow down on the flats fighting, and came to his rescue. They killed the third bear, laid Bruce out on the pilot house floor and doused his wounds with whiskey to prevent infection. They brought him to town, where the recovery process took years and two hip replacements.

Now as we climb into the skiff, my husband at the tiller, Bruce points to the flats where the attack took place.

"Over by that willow bar," he says.

He also points out a cliff at the entrance to the river. On the steep gray rock is a red-stained pictograph, an Indian drawing that is so old even the old-timers say it's been there forever.

At the rustic lodge called Unuk River Post we meet Bruce's friends, but don't stay long for it is getting dark. As we head back, it is difficult to find the river channel, which can change from day to day and hour to hour, and Bruce stands in the bow, directing my husband, first to the left, then the right. Fog drifts in and out as we maneuver around sub-merged snags and sand bars.

Finally we round a bend and the lights of the DUCHESS appear. "Next time," Bruce yells as the engine slows, "we'll borrow a jet boat and go all the way to Lake Creek!"

This is just one of several trips Bruce has planned. Though now 86, he plans to visit Smeaton Bay to look for an old jawbone he found 40 years ago and left on a rock ledge and to stop by Yes Bay to search for a cache of gold buried in the 1920s by an old character named "Yes Bay Johnnie."

I'm looking forward to the trips too, and making him the subject of future magazine articles.

At dinner on the last night Bruce comments that if he could turn back the tide and live his life over, he wouldn't change a thing. He has trapped, logged, hunted, guided, prospected and panned for gold. He has been a fisherman, mill worker, husband and father. The only thing he has not done, he says, is fish for halibut on a big halibut schooner.

Louise Brinck Harrington is an author and freelance writer living in Ketchikan, Alaska.

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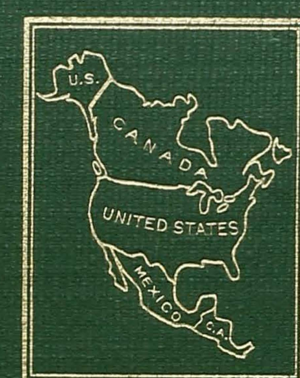
REPORT

INTERNATIONAL BOUNDARY COMMISSION

ESTABLISHMENT OF THE BOUNDARY BETWEEN

CANADA AND THE UNITED STATES

TONGASS PASSAGE TO MOUNT ST. ELIAS



DEPARTMENT OF STATE

1952

THE GRAND PACIFIC GLACIER FRONT IN 1929

The boundary line across Tarr Inlet is shown by a broken white line. From left to right, Boundary Points 163 (Mount Quincy Adams), 164 (Mount Fairweather), 162 (Mount Turner), 161, and 165 (Mount Root) are shown circled in black. Photograph by the United States Navy.

INTERNATIONAL BOUNDARY COMMISSION

JOINT REPORT

UPON THE

SURVEY AND DEMARCATION OF THE BOUNDARY

BETWEEN

CANADA AND THE UNITED STATES
FROM TONGASS PASSAGE TO MOUNT ST. ELIAS

IN ACCORDANCE WITH THE CONVENTION OF JANUARY 24, 1903; THE AWARD OF THE TRIBUNAL, APPOINTED UNDER THE CONVENTION, SIGNED AT LONDON, OCTOBER 20, 1903; AN EXCHANGE OF NOTES BETWEEN THE GOVERNMENTS OF GREAT BRITAIN AND THE UNITED STATES RELATIVE TO THE AWARD, SIGNED AT WASHINGTON, MARCH 25, 1905; AND THE TREATY SIGNED AT WASHINGTON, FEBRUARY 24, 1925

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INTRODUCTION

This report on the establishment of the International Boundary line between Canada and the United States territory of Alaska, from Tongass Passage to Mount St. Elias, is submitted in accordance with Article VI of the Convention of January 24, 1903; the Award of the Alaska Boundary Tribunal, signed October 20 of the same year; the exchange of notes between Great Britain and the United States relative to the Award, signed at Washington, March 25, 1905; and Article IV of the Treaty of 1925.

Although the first move to have the boundary line established between Canada and Alaska was made in 1872, no definite action towards undertaking a survey for that purpose was taken until 20 years later, when a convention was signed in Washington. Article I of the convention of 1892 stipulated that a "coincident or joint survey" should be made of the territory adjacent to the boundary line between latitude 54° 40′ north and the point where it intersects the 141st Meridian. A joint survey commission was accordingly formed, which functioned from 1893 to 1895. In carrying out their survey the commissioners adopted the newly developed phototopographic method, particularly suitable to a country abounding in precipitous mountains, deeply crevassed glaciers, treacherous snow fields, and swift, uncertain glacial streams flowing in part through deep canyons, where the methods of topographic surveying generally employed in less rugged terrain would be extremely difficult and slow.

When the members of the Alaska Boundary Tribunal were in session they had before them duplicate signed copies of the maps accompanying the report of the commission of 1893-1895, and on these they marked the course the boundary line was to take. East of Stephens Passage, however, they left parts of the line undefined, as the topography on the commission's maps in that area did not extend far enough eastward. The task of identifying and marking the boundary line as decided on by the Tribunal, and of defining the parts not specifically indicated by them, devolved upon the newly appointed International Boundary Commissioners, O. H. Tittmann for the United States, and W. F. King for Canada.

The field work of delimiting, marking, and defining this section of the International Boundary line was started in 1904. It comprised in general the extension of nets of triangulation to the boundary area from the U.S. Coast and Geodetic Survey triangulation along the coast, identification of the boundary points of the Award and the exchange of notes and the projection where practicable of straight lines between them, phototopographic surveys additional to those made by the commission of 1893-95 of the country adjacent to the boundary line, setting monuments at suitable sites to mark the boundary, connecting the boundary points with the triangulation for the computation of their geographic positions, and cutting a 20-foot wide vista along the line in timbered areas. The nature of the terrain was such that the boundary could be most easily reached by way of the numerous inlets, rivers, and glaciers penetrating the coast, and as direct communication along the boundary between any one river or glacier and the next was so difficult as to be practically impossible, the work was done by isolated parties, Canadian and United States, until the virtual completion of the demarcation of the land section of the boundary in 1912. During the years 1913-1914 the demarcation of the remaining water boundary was completed by a Canadian party. Some minor adjustments to the line were made and some further field work was done by Canadian and United States parties in 1920. Maintenance in later years has been carried on under the provisions of Article IV of the treaty of 1925.

The geographic positions of the boundary points and turning points, and the boundary triangulation stations were originally based on the Southeast Alaska datum. Later it was found necessary that they should be based on the 1927 North American datum. As the duties of the Commissioners had been increased by the treaties of 1908 and 1925 to include the work of surveying, marking, and maintaining the entire boundaries between Canada and the United States, the necessity of work elsewhere after the completion of the field work from Tongass Passage to Mount St. Elias in 1920 did not allow the dispatch of field parties to that distant region. Consequently, the field work of connecting boundary stations with those of the United States Coast and Geodetic Survey based on the new datum in the coastal regions was done at convenient times by co-operative arrangement between the Commissioners, the Geodetic Survey of Canada, and the United States Coast and Geodetic Survey.

The land section of the boundary is marked by 192 boundary points, and there are 29 boundary turning points in the water section referenced by 53 monuments. The total length of the boundary from the point B of the award at the mouth of Tongass Passage to the southern extremity of the 141st Meridian boundary on the west shoulder of Mount St. Elias is 808·2 miles, of which 98·4 miles is over water and 709·8 miles is over land. The preparation of the 13 topographic maps that accompany this report is described on pages 145 and 146. The area covered by the contoured parts of the maps is about 32,000 square miles, about two-thirds of which is above tree line, and about one-third is perpetually covered by snow or ice.

CONVENTION SIGNED AT WASHINGTON, JANUARY 24, 1903, FOR THE ADJUSTMENT OF THE BOUNDARY BETWEEN THE DOMINION OF CANADA AND THE TERRITORY OF ALASKA

His Majesty the King of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas, Emperor of India, and the United States of America, equally desirous for the friendly and final adjustment of the differences which exist between them in respect to the true meaning and application of certain clauses of the Convention between Great Britain and Russia, signed under date of the 28th (16th) February, A.D. 1825, which clauses relate to the delimitation of the boundary line between the territory of Alaska, now in possession of the United States, and the British possessions in North America, have resolved to provide for the submission of the questions as hereinafter stated to a Tribunal, and to that end have appointed their respective Plenipotentiaries, as follows:

His Britannic Majesty, the Right Honourable Sir Michael H. Herbert, K.C.M.G., C.B., His Britannic Majesty's Ambassador Extraordinary and Plenipotentiary; and

The President of the United States of America, John Hay, Secretary of State of the United States;

Who, after an exchange of their full powers, which were found to be in good and due form, have agreed upon the following Articles:

ARTICLE I

A Tribunal shall be immediately appointed to consider and decide the questions set forth in Article IV of this Convention. The Tribunal shall consist of six impartial jurists of repute, who shall consider judicially the questions submitted to them, each of whom shall first subscribe an oath that he will impartially consider the arguments and evidence presented to the Tribunal, and will decide thereupon according to his true judgment. Three members of the Tribunal shall be appointed by His Britannic Majesty and three by the President of the United States. All questions considered by the Tribunal, including the final award, shall be decided by a majority of all the members thereof.

In case of the refusal to act, or of the death, incapacity, or abstention from service of any of the persons so appointed, another impartial jurist of repute shall be forthwith appointed in his place by the same authority which appointed his predecessor.

The Tribunal may appoint a Secretary and a Bailiff to perform such duties as they may prescribe, and may employ scientific experts if found to be necessary, and may fix a reasonable compensation for such officers. The Tribunal shall keep an accurate record of all its proceedings.

Each of the High Contracting Parties shall make compensation for the services of the members of the Tribunal of its own appointment and of any agent, counsel, or other person employed in its behalf, and shall pay all costs incurred in the preparation of its Case. All expenses reasonably incurred by the Tribunal in the performance of its duties shall be paid by the respective Governments in equal moieties.

The Tribunal may, subject to the provisions of this Convention, establish all proper rules for the regulation of its proceedings.

ARTICLE II

Each of the High Contracting Parties shall also name one person to attend the Tribunal as its Agent.

The written or printed Case of each of the two parties, accompanied by the documents, the official correspondence, and all other evidence in writing or print on which each Party relies,

91264—2

shall be delivered in duplicate to each member of the Tribunal and to the Agent of the other Party as soon as may be after the organization of the Tribunal but within a period not exceeding two months from the date of the exchange of ratifications of this Convention.

Within two months after the delivery on both sides of the written or printed Case, either Party may, in like manner, deliver in duplicate to each member of the Tribunal, and to the Agent of the other Party, a Counter-Case, and additional documents, correspondence and evidence, in reply to the Case, documents, correspondence and evidence so presented by the other Party. The Tribunal may, however, extend this last mentioned period when in their judgment it becomes necessary, by reason of special difficulties which may arise in the procuring of such additional papers and evidence.

If in the Case submitted to the Tribunal either Party shall have specified or referred to any report or document in its own exclusive possession without annexing a copy, such Party shall be bound, if the other Party shall demand it, within thirty days after the delivery of the Case, to furnish to the Party applying for it a duly certified copy thereof: and either Party may call upon the other, through the Tribunal, to produce the original or certified copies of any papers adduced as evidence, giving in each instance such reasonable notice as the Tribunal may require; and the original or copy so requested shall be delivered as soon as may be and within a period not exceeding forty days after receipt of notice.

Each Party may present to the Tribunal all pertinent evidence, documentary, historical, geographical, or topographical, including maps and charts, in its possession or control and applicable to the rightful decision of the questions submitted; and if it appears to the Tribunal that there is evidence pertinent to the Case in the possession of either Party, and which has not been produced, the Tribunal may in its discretion order the production of the same by the Party having control thereof.

It shall be the duty of each Party, through its Agent, or Counsel, within two months from the expiration of the time limited for the delivery of the Counter-Case on both sides, to deliver in duplicate to each member of the said Tribunal and to the Agent of the other Party a written or printed argument showing the points and referring to the evidence upon which his Government relies, and either Party may also support the same before the Tribunal by oral argument of Counsel. The Tribunal may, if they shall deem further elucidation with regard to any point necessary, require from either Party a written, printed, or oral statement or argument upon the point; but in such case the other Party shall have the right to reply thereto.

Article III

It is agreed by the High Contracting Parties that the Tribunal shall consider in the settlement of the questions submitted to its decisions the Treaties respectively concluded between His Britannic Majesty and the Emperor of All the Russias under date of the 28th (16th) February, A.D. 1825, and between the United States of America and the Emperor of All the Russias, concluded under date of the 30th (18th) March, A.D. 1867, and particularly the Articles III, IV and V of the first-mentioned Treaty, which in the original text are, word for word, as follows:

> "III. La ligne de démarcation entre les possessions des Hautes Parties Contractantes sur la côte du Continent et les Iles de l'Amérique Nord-ouest, sera tracée ainsi qu'il suit:—
>
> "A partir du point le plus méridional de l'île dite Prince of Wales, lequel point se trouve sous le parallèle du 54° 40′ de latitude nord, et entre le 131e et le 133e degré de longitude ouest (méridien de Greenwich), la dite ligne remontera au nord le long de la passe dite Portland Channel, jusqu'au point de la terre ferme où elle atteint le 56e degré de latitude nord; de ce dernier point la ligne de démarcation suivra la crête des montagnes situées parallèlement à la côte, jusqu'au point d'intersection du 141e degré de longitude ouest (même méridien); et, finalement, du dit point d'intersection, la même ligne méridienne du 141e degré formera, dans son prolongement jusqu'à la mer glaciale, la limite entre les possessions Russes et Britanniques sur le Continent de l'Amérique Nord-ouest.

"IV. Il est entendu par rapport à la ligne de démarcation déterminée dans l'Article précédent:—

"1. Que l'île dite Prince of Wales appartiendra tout entière à la Russie.

"2. Que partout où la crête des montagnes qui s'étendent dans une direction parallèle à la côte depuis le 56e degré de latitude nord au point d'intersection du 141e degré de longitude ouest se trouverait à la distance de plus de dix lieues marine de l'Océan, la limite entre les possessions Britanniques et la lisière de côte mentionnée ci-dessus comme devant appartenir à la Russie sera formée par une ligne parallèle aux sinuosités de la côte, et qui ne pourra jamais en être éloignée que de dix lieues marines.

"V. Il est convenu, en outre, que nul établissement ne sera formé par l'une des deux Parties dans les limites que les deux Articles précédents assignent aux possessions de l'autre. En conséquence, les sujets britanniques ne formeront aucun établissement soit sur la côte, soit sur la lisière de terre ferme comprise dans les limites des possessions Russes, telles qu'elles sont désignées dans les deux Articles précédents; et, de même, nul établissement ne sera formé par des sujets Russes au delà des dites limites."[1]

The Tribunal shall also take into consideration any action of the several Governments or of their respective Representatives preliminary or subsequent to the conclusion of said Treaties, so far as the same tends to show the original and effective understanding of the Parties in respect to the limits of their several territorial jurisdictions under and by virtue of the provisions of said Treaties.

Article IV

Referring to Articles III, IV, and V of the said Treaty of 1825, the said Tribunal shall answer and decide the following questions:

1. What is intended as the point of commencement of the line?

2. What channel is the Portland Channel?

3. What course should the line take from the point of commencement to the entrance to Portland Channel?

4. To what point on the 56th parallel is the line to be drawn from the head of Portland Channel, and what course should it follow between these points?

5. In extending the line of demarcation northward from said point on the parallel of the 56th degree of north latitude, following the crest of the mountains situated parallel to the coast until its intersection with the 141st degree of longitude west of Greenwich, subject to the condition that if such line should anywhere exceed the distance of 10 marine leagues from the ocean then the boundary between the British and Russian territory should be formed by a line parallel to the sinuosities of the coast and distant therefrom not more than 10 marine leagues, was it the intention and meaning of said Convention of 1825 that there should remain in the exclusive possession of Russia a continuous fringe or strip of coast on the mainland, not exceeding 10 marine leagues in width, separating the British possessions from the bays, ports, inlets, havens, and waters of the ocean, and extending from the said point on the 56th degree of latitude north to a point where such line of demarcation should intersect the 141st degree of longitude west of the meridian of Greenwich?

6. If the foregoing question should be answered in the negative, and in the event of the summit of such mountains proving to be in places more than 10 marine leagues from the coast, should the width of the *lisière* which was to belong to Russia be measured (1) from the mainland coast of the ocean, strictly so-called, along a line perpendicular thereto, or (2) was it the intention and meaning of the said Convention that where the mainland coast is indented by deep inlets forming part of the territorial waters of Russia, the width of the *lisière* was to be measured (a) from the line of the general direction of the mainland coast, or (b) from the line separating the waters of the ocean from the territorial waters of Russia, or (c) from the heads of the aforesaid inlets?

[1] For the translation of these articles, *See* the full text of the Treaty of 1825 on page 194.

7. What, if any exist, are the mountains referred to as situated parallel to the coast, which mountains, when within 10 marine leagues from the coast, are declared to form the eastern boundary?

Article V

The Tribunal shall assemble for their first meeting at London as soon as practicable after receiving their commissions, and shall themselves fix the times and places of all subsequent meetings.

The decision of the Tribunal shall be made as soon as possible after the conclusion of the arguments in the Case, and within three months thereafter, unless His Britannic Majesty and the President of the United States shall by common accord extend the time therefor. The decision shall be made in writing and dated, and shall be signed by the members of the Tribunal assenting to the same. It shall be signed in duplicate, one copy whereof shall be given to the Agent of His Britannic Majesty for his Government, and the other to the Agent of the United States of America for his Government.

Article VI

When the High Contracting Parties shall have received the decision of the Tribunal upon the questions submitted as provided in the foregoing Articles, which decision shall be final and binding upon all Parties, they will at once appoint, each on its own behalf, one or more scientific experts, who shall with all convenient speed, proceed together to lay down the boundary-line in conformity with such decision.

Should there be, unfortunately, a failure by a majority of the Tribunal to agree upon any of the points submitted for their decision, it shall be their duty to so report in writing to the respective Governments through their respective Agents. Should there be an agreement by a majority upon a part of the questions submitted, it shall be their duty to sign and report their decision upon the points of such agreement in the manner hereinbefore prescribed.

Article VII

The present Convention shall be ratified by His Britannic Majesty, and by the President of the United States, by and with the advice and consent of the Senate, and the ratifications shall be exchanged in London or in Washington as soon as the same may be effected.

In faith whereof we, the respective Plenipotentiaries, have signed this Convention, and have hereunto affixed our Seals.

Done at Washington, in duplicate, this 24th day of January, A.D. 1903.

(Signed) Michael H. Herbert.
(Signed) John Hay.

THE ALASKA BOUNDARY TRIBUNAL AWARD

Whereas by a Convention signed at Washington on the 24th day of January, 1903, by Plenipotentiaries of and on behalf of His Majesty the King of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas, Emperor of India, and of and on behalf of the United States of America, it was agreed that a Tribunal should be appointed to consider and decide the questions hereinafter set forth, such Tribunal to consist of six impartial Jurists of repute, who should consider judicially the questions submitted to them, each of whom should first subscribe an oath that he would impartially consider the arguments and evidence presented to the said Tribunal, and would decide thereupon according to his true judgment, and that three members of the said Tribunal should be appointed by His Britannic Majesty and three by the President of the United States;


MAP SHOWING AWARD OF
ALASKA BOUNDARY TRIBUNAL
OCTOBER 20, 1903.
Published at Washington, D.C.
FOR THE DEPARTMENT OF STATE
BY THE COAST AND GEODETIC SURVEY
O. H. Tittmann, Superintendent
November, 1903.
Statute Miles
Marine Leagues
MALASPINA GLACIER
Yakutat Bay
Hering Bay
Alsek River
Cape Fairweather
Cape Spencer
Cross Sound
Cape Bingham
ICY STRAIT
CHICHAGOF ISLAND
BARANOF ISLAND
ADMIRALTY
CHATHAM STRAIT
LYNN CANAL
Dyea
Skagway
White Pass
Juneau
Douglas
Taku River
Teslin Lake
Inklin River
Stikine River
Iskoot River
Dease River
Liard River
FREDERICK SOUND
Stephens Passage
Cape Edgecumbe
SITKA
Norfolk or Sitka Sound
KUPREANOF ISLAND
KUIU ISLAND
Mitkof I.
Wrangell
Zarembo I.
Duke of York I.
Sumner Strait
Cape Ommaney
Christian Sound
IPHIGENIA BAY
PRINCE OF WALES ISLAND
CLARENCE STRAIT
REVILLA-GIGEDO ISLAND
PORTLAND CANAL
Observatory Inlet
Nass River
Cape Chacon
Cape Muzon
C. Northumberland
Cape Fox
Dundas
Port Simpson
DIXON ENTRANCE

And whereas it was further agreed by the said Convention that the said Tribunal should consider in the settlement of the said questions submitted to its decision the Treaties respectively concluded between His Britannic Majesty and the Emperor of all the Russias, under date of the 28th (16th) February, A.D. 1825, and between the United States of America and the Emperor of all the Russias, concluded under date of the 18th (30th) March, A.D. 1867, and particularly the Articles III, IV and V of the first-mentioned Treaty, and should also take into consideration any action of the several Governments or of their respective representatives, preliminary or subsequent to the conclusion of the said Treaties, so far as the same tended to show the original and effective understanding of the parties in respect to the limits of their several territorial jurisdictions under and by virtue of the provisions of the said Treaties;

And whereas it was further agreed by the said Convention, referring to Articles III, IV, and V of the said Treaty of 1825, that the said Tribunal should answer and decide the following questions:

1. What is intended as the point of commencement of the line?

2. What channel is the Portland Channel?

3. What course should the line take from the point of commencement to the entrance to Portland Channel?

4. To what point on the 56th parallel is the line to be drawn from the head of the Portland Channel, and what course should it follow between these points?

5. In extending the line of demarcation northward from the said point on the parallel of the 56th degree of north latitude, following the crest of the mountains situated parallel to the coast until its intersection with the 141st degree of longitude west of Greenwich, subject to the conditions that if such line should anywhere exceed the distance of 10 marine leagues from the ocean, then the boundary between the British and Russian territory should be formed by a line parallel to the sinuosities of the coast and distant therefrom not more than 10 marine leagues, was it the intention and meaning of the said Convention of 1825 that there should remain in the exclusive possession of Russia a continuous fringe, or strip, of coast on the mainland, not exceeding 10 marine leagues in width, separating the British possessions from the bays, ports, inlets, havens, and waters of the ocean, and extending from the said point on the 56th degree of latitude north to a point where such line of demarcation should intersect the 141st degree of longitude west of the meridian of Greenwich?

6. If the foregoing question should be answered in the negative, and in the event of the summit of such mountains proving to be in places more than 10 marine leagues from the coast, should the width of the *lisière*, which was to belong to Russia, be measured (1) from the mainland coast of the ocean, strictly so-called, along a line perpendicular thereto, or (2) was it the intention and meaning of the said Convention that where the mainland coast is indented by deep inlets forming part of the territorial waters of Russia, the width of the *lisière* was to be measured (a) from the line of the general direction of the mainland coast, or (b) from the line separating the waters of the ocean from the territorial waters of Russia, or (c) from the heads of the aforesaid inlets?

7. What, if any exist, are the mountains referred to as situated parallel to the coast, which mountains, when within 10 marine leagues from the coast, are declared to form the eastern boundary?

And whereas His Britannic Majesty duly appointed Richard Everard, Baron Alverstone, G.C.M.G., Lord Chief Justice of England, Sir Louis Amable Jetté, K.C.M.G., Lieutenant-Governor of the Province of Quebec, and Allen Bristol Aylesworth, one of His Majesty's Counsel; and the President of the United States of America duly appointed the Honourable Elihu Root, Secretary of War of the United States, the Honourable Henry Cabot Lodge, Senator of the United States from the State of Massachusetts, and the Honourable George Turner, of the State of Washington, to be members of the said Tribunal:

Now, therefore, we, the Undersigned, having each of us first subscribed an oath, as provided by the said Convention, and having taken into consideration the matters directed by the said

Convention to be considered by us, and having judicially considered the said questions submitted to us, do hereby make Answer and Award as follows:

In answer to the first question—

The Tribunal unanimously agrees that the point of commencement of the line is Cape Muzon.

In answer to the second question—

The Tribunal unanimously agrees that the Portland Channel is the channel which runs from about 55°56′ north latitude, and passes to the north of Pearse and Wales Island.

A majority of the Tribunal, that is to say, Lord Alverstone, Mr. Root, Mr. Lodge, and Mr. Turner, decides that the Portland Channel, after passing to the north of Wales Island, is the channel between Wales Island and Sitklan Island, called Tongass Channel. The Portland Channel above mentioned is marked throughout its length by a dotted red line from the point B to the point marked C on the map signed in duplicate by the Members of the Tribunal at the time of signing their decision.

In answer to the third question—

A majority of the Tribunal, that is to say, Lord Alverstone, Mr. Root, Mr. Lodge, and Mr. Turner, decides that the course of the line from the point of commencement to the entrance to Portland Channel is the line marked A B in red on the aforesaid map.

In answer to the fourth question—

A majority of the Tribunal, that is to say, Lord Alverstone, Mr. Root, Mr. Lodge, and Mr. Turner, decides that the point to which the line is to be drawn from the head of the Portland Channel is the point on the 56th parallel of latitude marked D on the aforesaid map, and the course which the line should follow is drawn from C to D on the aforesaid map.[1]

In answer to the fifth question—

A majority of the Tribunal, that is to say, Lord Alverstone, Mr. Root, Mr. Lodge, and Mr. Turner, decides that the answer to the above question is in the affirmative.

Question five having been answered in the affirmative, question six requires no answer.

In answer to the seventh question—

A majority of the Tribunal, that is to say, Lord Alverstone, Mr. Root, Mr. Lodge, and Mr. Turner, decides that the mountains marked S on the aforesaid map are the mountains referred to as situated parallel to the coast on that part of the coast where such mountains marked S are situated, and that between the points marked P (mountain marked S, 8,000) on the north, and the point marked T (mountain marked S, 7,950) in the absence of further survey, the evidence is not sufficient to enable the Tribunal to say which are the mountains parallel to the coast within the meaning of the Treaty.[2]

In witness whereof we have signed the above-written decision upon the questions submitted to us.

Signed in duplicate this 20th day of October, 1903.

Alverstone.
Elihu Root.
Henry Cabot Lodge.
George Turner.

Witness:
Reginald Tower,
Secretary.

Certified to be in conformity with the original.

London, October 22nd, 1903.

(L.S.)
Foreign Office.

T. H. Sanderson,
Under Secretary of State for Foreign Affairs.

[1] C = Boundary Point No. 1, D = Boundary Point No. 7.
[2] P = Boundary Point No. 93, T = Boundary Point No. 72.

LETTERS RELATIVE TO THE COMMISSIONERS APPOINTED FOR THE DELIMITATION OF THE BOUNDARY BETWEEN CANADA AND ALASKA IN CONFORMITY WITH THE AWARD OF THE ALASKA BOUNDARY TRIBUNAL

PRIVY COUNCIL

CANADA

From Sir H. M. Durand to Lord Minto

British Embassy,
Washington,
February 6th, 1904.

My Lord: In compliance with telegraphic instructions which I received from His Majesty's Principal Secretary of State for Foreign Affairs I addressed on the 29th ultimo a Note to the Acting Secretary of State of the United States informing him that Your Excellency's Government were ready to enter into arrangements for the delimitation of the boundary between the Dominion of Canada and the Territory of Alaska in conformity with the award of the Alaska Boundary Tribunal, and that they proposed to appoint Mr. King as their representative on the delimitation Commission. I added that Mr. King would be ready to meet the expert named by the United States Government as soon as the appointment of the latter was made.

I now have the honour to transmit to Your Excellency herewith copy of a note which I have received from Mr. Loomis, stating that Mr. O. H. Tittmann, Superintendent of the Coast and Geodetic Survey, has been designated by the United States Government as their representative on the delimitation Commission, and suggesting, in view of the brief season in which work can be done to advantage, the expediency of an early conference between Mr. King and Mr. Tittmann.

I have informed His Majesty's Principal Secretary of State for Foreign Affairs by telegraph of Mr. Tittmann's appointment.

I have, etc.,

(Sgd.) H. M. Durand.

Department of Commerce and Labor
Office of the Secretary, Washington

February 11, 1904.

Sir: At the instance of the Secretary of State you are hereby designated to serve as this Government's expert representative on the Delimitation Commission for the tracing of the boundary between Alaska and Canada in conformity with the award of the Alaskan Boundary Tribunal which recently sat in London.

Respectfully,

Geo. B. Cortelyou,
Secretary.

Hon. O. H. Tittmann,
Superintendent, Coast and Geodetic Survey,
Department of Commerce and Labor.

OTTAWA, 19th February, 1904.

To

HIS EXCELLENCY

THE GOVERNOR GENERAL IN COUNCIL:

The undersigned has the honour to acknowledge receipt of the despatch, which has been referred to him, addressed to Your Excellency by His Majesty's Ambassador to the United States under date the 6th February.

His Majesty's Ambassador states that he has informed the Acting Secretary of State of the United States that Your Excellency's Government is ready to enter into arrangements for the delimitation of the boundary between the Dominion of Canada and the Territory of Alaska in conformity with the award of the Alaska Boundary Tribunal, and that they have appointed Mr. King as their representative on the Delimitation Commission. He further states that, in reply to his note, he has been informed that Mr. O. H. Tittmann, Superintendent of the Coast and Geodetic Survey, has been designated by the United States Government as their representative, and that the suggestion has been made to him by the Acting Secretary of State that, owing to the brief season in which work can be done to advantage, an early conference between Messrs. Tittmann and King, in order that work may be begun without undue delay, is expedient.

The undersigned has the honour to report that Mr. King has been instructed to communicate with Mr. Tittmann, for the purpose of arranging a meeting at which preparations for the early execution of the work may be made. Further, he begs to recommend that Your Excellency be moved to transmit copies of this Minute to His Majesty's Ambassador to the United States and to His Majesty's Principal Secretary of State for the Colonies.

Respectfully submitted,

(Sgd.) CLIFFORD SIFTON,
Minister of the Interior.

REPORT OF THE COMMISSIONERS RELATIVE TO THE PART OF THE BOUNDARY BETWEEN CANADA AND ALASKA LYING BETWEEN THE POINTS "P" AND "T" MENTIONED IN THE AWARD OF THE ALASKA BOUNDARY TRIBUNAL

We, the undersigned Commissioners on behalf of His Britannic Majesty and of the United States, respectively, having met to discuss the demarcation of the boundary line between Alaska and Canada, have considered the part lying between the points P and T mentioned in the Award of the Tribunal of 1903.

We respectfully recommend that the boundary between these points be marked by the summits whose geographical co-ordinates are given in the attached table, with the proviso that between the points 7 and 8, and 8 and T, where the distances between the peaks given in the table exceed the probable limit of intervisibility, power be granted to the Commissioners after they have secured sufficient data, to select additional and intermediate peaks, no such peak to be more than twenty-five hundred meters from the straight line joining peaks 7 and 8, or 8 and T of the attached table.

(Sgd.) W. F. KING,
H.B.M. Commissioner.

(Sgd.) O. H. TITTMANN,
U.S. Commissioner.

WASHINGTON, D.C.,
April 12, 1904.

TABLE SHOWING POSITIONS AND DISTANCES OF PEAKS

The latitudes and longitudes are taken from the maps Nos. 10 and 12 of the Surveys made by the British Commission under the Convention of 1892. The successive peaks are designated by consecutive numbers, counting southward from point P.

Points	Latitude			Longitude			Distances		
							From	To	Metres
Sheet 12	°	′	″	°	′	″			
1	58	36	29	133	41	55	P	1	15,840
2	58	31	01	133	33	14	1	2	12,800
3	58	24	40	133	26	09	2	3	13,680
4	58	22	35	133	27	09	3	4	4,000
5	58	16	10	133	21	08	4	5	13,200
6	58	13	24	133	16	48	5	6	6,960
7	58	09	07	133	11	10	6	7	9,700
Sheet 10		—			—		7	8	81,440
8	57	29	47	132	32	52	8	T	36,800

NOTE: P = Boundary Point No. 93; 1 = No. 92; 2 = No. 87; 3 = No. 86; 4 = No. 85; 5 = No. 84; 6 = No. 83; 7 = No. 79; 8 = No. 74; and T = No. 72.

EXCHANGE OF NOTES BETWEEN THE BRITISH AND UNITED STATES GOVERNMENTS, RELATIVE TO THE ACCEPTANCE OF THE REPORT OF THE COMMISSIONERS TO COMPLETE THE ALASKA BOUNDARY TRIBUNAL AWARD

UNITED STATES ACTING SECRETARY OF STATE TO H.M. AMBASSADOR AT WASHINGTON

DEPARTMENT OF STATE, WASHINGTON, March 25, 1905.

EXCELLENCY,

Referring to your note of the 1st October, and Mr. Hay's reply of the 2nd of December, 1904, in regard to the report by Messrs. O. H. Tittmann and W. F. King, the Commissioners appointed to carry out the delimitation of the Alaska Boundary so far as it was left undefined by the Award of the London Tribunal, and concerning the character of an Agreement between the United States and Great Britain for the formal acceptance of the recommendations of the Commissioners by an exchange of notes, I have the honor to state, by direction of the President, that the Government of the United States agrees with the Government of His Britannic Majesty that the part of the boundary between Alaska and Canada lying between the points P and T mentioned in the Award of the Tribunal of 1903 shall be defined, in accordance with the general principles laid down by said Tribunal, by the summits whose geographical co-ordinates are given with sufficient approximation for identification in the attached table, provided that the Commissioners are hereby empowered, after they have secured sufficient data, to select additional and intermediate peaks between the points 7 and 8 and 8 and T where the distances between the peaks given in the table exceed the probable limit of intervisibility: Provided also that no such additional and intermediate peaks shall be more than 2,500 metres from the straight line joining peaks 7 and 8 or 8 and T of the attached table, as follows:

TABLE SHOWING THE POSITIONS AND DISTANCES OF PEAKS

The latitudes and longitudes are taken from, and refer to, the maps Nos. 10 and 12 of the surveys made by the British Commission under the Convention of 1892. The successive peaks are designated by consecutive numbers, counting southward from point P.

Points	Latitude			Longitude			Approximate distances		
							From	To	Metres
Sheet 12	°	′	″	°	′	″			
1	58	36	29	133	41	55	P	1	15,840
2	58	31	01	133	33	14	1	2	12,800
3	58	24	40	133	26	09	2	3	13,680
4	58	22	35	133	27	09	3	4	4,000
5	58	16	10	133	21	08	4	5	13,200
6	58	13	24	133	16	48	5	6	6,960
7	58	09	07	133	11	10	6	7	9,700
Sheet 10		—			—		7	8	81,440
8	57	29	47	132	32	52	8	T	36,800[1]

[1] *See* note on page 9.

Your acknowledgment of this communication, with a similar statement on behalf of the Government of His Majesty, will complete the agreed exchange of notes, and will confirm and give validity to the agreement reached by the Commissioners, thus completing the Award of the London Tribunal under the Convention of the 24th January, 1903, as to the above-described part of the Alaska boundary.

Expressing the President's satisfaction at this settlement of the matter, I have, &c.

ALVEY A. ADEE,
Acting Secretary of State.

SIR H. M. DURAND.

H.M. AMBASSADOR AT WASHINGTON TO UNITED STATES SECRETARY OF STATE

BRITISH EMBASSY, Washington, March 25, 1905.

SIR,—I have the honour to acknowledge receipt of your note of this date in regard to the Report by Messrs. W. F. King and O. H. Tittmann, the Commissioners appointed to carry out the delimitation of the Alaska boundary so far as it was left undefined by the Award of the London Tribunal, and concerning the character of an agreement between Great Britain and the United States for the formal acceptance of the recommendations of the Commissioners by an exchange of notes.

By direction and on behalf of the Government of His Britannic Majesty, I have the honour to state that the Government of His Majesty agrees with the Government of the United States that the part of the boundary between Canada and Alaska lying between the points P and T, mentioned in the Award of the Tribunal of 1903, shall be defined, in accordance with the general principles laid down by said Tribunal, by the summits whose geographical co-ordinates are given with sufficient approximation for identification in the attached table, provided that the Commissioners are hereby empowered, after they have secured sufficient data, to select additional and intermediate peaks between the points 7 and 8 and 8 and T where the distances between the peaks given in the table exceed the probable limit of intervisibility: Provided also that no such additional and intermediate peak shall be more than 2,500 meters from the straight line joining peaks 7 and 8 and 8 and T of the attached tables, as follows:

TABLE SHOWING THE POSITIONS AND DISTANCES OF PEAKS

The latitudes and longitudes are taken from, and refer to, the maps Nos. 10 and 12 of the surveys made by the British Commission under the Convention of 1892. The successive peaks are designated by consecutive numbers, counting southward from point P.

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6	58	13	24	133	16	48	5	6	6,960
7	58	09	07	133	11	10	6	7	9,700
Sheet 10		—			—		7	8	81,440
8	57	29	47	132	32	52	8	T	36,800[1]

[1] *See* note on page 9.

I am instructed to express the gratification of my Government that, by this exchange of notes, confirmation and validity are given to the Agreement reached by the Commissioners, thus completing the Award of the London Tribunal under the Convention of the 24th January, 1903, as to the above-described part of the Alaska Boundary.

I have, &c.,

H. M. DURAND.

The Hon. JOHN HAY.

RESERVATION OF LANDS ALONG THE INTERNATIONAL BOUNDARY

ACTION TAKEN BY THE GOVERNMENT OF THE DOMINION OF CANADA

P.C. 810

Ref. 1,569,421 on 1301 (7).

Certified copy of a Report of the Committee of the Privy Council, approved by His Excellency the Administrator on the 14th April, 1908.

On a report dated 1st April, 1908, from the Minister of the Interior with reference to a Despatch from His Majesty's Ambassador at Washington, dated 30th October, 1907, submitting for the consideration of the Dominion Government a proposal by the United States Government that joint action be taken for the reservation of a strip of land sixty feet wide on each side of the

Canada-Alaska boundary line under similar conditions to that formerly established along the Mexican boundary line by Proclamation of the President of the United States.

The Minister of the Interior submits that in his opinion such a reservation will be of great service in the protection of the revenue and in the enforcement of the law generally, and he therefore recommends that with a view to the prevention of the erection of building or permanent structures or works on or close to the boundary line, except railways, aqueducts, bridges, canals, ditches and other works of a public character and except buildings or permanent structures or works properly connected with such railways, aqueducts, bridges, canals and other works of a public character, to be authorized to reserve the land within a strip sixty feet wide along the boundary line between Canada and Alaska from sale, lease and entry so far as the lands in question are vested in the Dominion.

The Minister points out that the title to wild lands adjacent to the Canada-Alaska boundary line is vested in the Dominion to the northward only of the sixtieth parallel of latitude. South of the parallel the lands lie in the province of British Columbia and the title to the crown lands is vested in the province.

The Minister has reason to believe, however, that the province of British Columbia will be willing to give its co-operation.

In connection with this subject the Minister of the Interior desires to suggest consideration of the possibility of making a similar reservation along other parts of the common boundary line, which, besides extensive stretches of water boundary, comprises some 1,900 miles on land.

Of the 1,300 miles or thereabouts from the Strait of Georgia to the Lake of the Woods, some 400 miles lie west of the summit of the Rocky Mountains. Along this distance the Minister understands that the Government of British Columbia has already reserved a strip 66 feet wide, wherever the land has not already been disposed of, along the International Boundary Line. East of the Rocky Mountains, under the original surveys made by the Dominion Government, road allowances were left adjoining the boundary. These road allowances are no longer under the control of the Dominion Government, having now passed under the jurisdiction of the provinces of Alberta, Saskatchewan and Manitoba.

The four provinces mentioned would doubtless agree to make the road allowances and the reservation permanent, though to secure that end, concurrent agreement by the United States or by the several states affected, to reserve a similar strip would appear to be desirable.

The Minister states that along the line from the St. Lawrence River to the St. Croix the natural difficulty of enforcing the laws of the two countries along an extensive boundary line is enhanced by the fact that the property adjacent to the line, on both sides, has passed into private hands, and at many points there exist so-called "line houses" which stand close to or upon the line, and which in many instances, as has been charged, have been used for smuggling or for evasion of law, to a serious extent. While it may not be practicable, by reason of the expense which it would involve to apply the effective remedy of removing these houses altogether, it is a matter for consideration whether there are any steps which the two Governments could take to prevent the erection in future of further houses of this kind.

The Committee, concurring in the foregoing, advise that His Excellency be moved to forward a copy hereof to His Majesty's Ambassador at Washington, with a request that he inform the Government of the United States that the Dominion Government is in full accord with the principle of their proposal, and will take steps to give effect to the reservation along the frontier of the Yukon Territory, and that he further call attention to the suggestion herein contained relative to other parts of the International Boundary Line.

All which is respectfully submitted for approval.

RODOLPHE BOUDREAU,
Clerk of the Privy Council.

To the Honourable
THE MINISTER OF THE INTERIOR.

P.C. No. 2235 M.

Ref. 1,633,875 on 1,301 (8).

Certified copy of a Report of the Committee of the Privy Council, approved by His Excellency the Governor General on the 7th August, 1908.

The Committee of the Privy Council have had under consideration a despatch, dated 22nd June, 1908, from His Majesty's Ambassador to the United States, transmitting copy of a proclamation by the President of the United States setting apart as a public reservation all unpatented lands of the United States lying within sixty feet of the boundary line between the United States and Canada. His Majesty's Ambassador draws attention to the fact that the original proposal for reservation of the Alaska frontier has now been extended so as to include the whole frontier, this being in accordance with the wishes of the Dominion Government.

The Minister of the Interior, to whom the said despatch was referred, states that under the authorization of the Order in Council of 14th April, 1908, he has withdrawn from sale, lease and entry, all public lands lying within sixty feet of the International Boundary in Yukon Territory.

The Minister recommends that the matter be brought to the attention of the Government of the province of British Columbia, which with a view to the better enforcement of the laws of that province as well as of the Dominion may find it advisable to make a similar reservation along the boundary between British Columbia and Alaska and along the 49th parallel.

In view of the fact that the lands in the road allowance which was laid off in the original surveys of Dominion Lands along the International Boundary in the Provinces of Manitoba, Saskatchewan, and Alberta, have been transferred to these provinces, the Minister further recommends that the matter be brought to the attention of the respective Provincial Governments with the suggestion that this road allowance be retained for public use only.

The Committee, concurring in the foregoing, submit the same for approval and advise that Your Excellency may be pleased to transmit the substance of this Minute, if approved, to His Majesty's Ambassador at Washington for the information of the United States Government.

RODOLPHE BOUDREAU,
Clerk of the Privy Council.

To the Honourable
THE MINISTER OF THE INTERIOR.

Published in The Canada Gazette of 3rd April, 1909, vol. 42, for the fourth consecutive week.

PROCLAMATIONS BY THE PRESIDENT OF THE UNITED STATES OF AMERICA

(No. 810)

Whereas, the customs and immigration laws of the United States can be better enforced and the public welfare thereby better advanced when the Federal Government has complete control of the use and occupation of lands abutting on international boundary lines;

Now, therefore, I, Theodore Roosevelt, President of the United States, do hereby proclaim and make known that all unpatented public lands of the United States, lying within sixty feet of the boundary line between the United States and the Dominion of Canada, are hereby declared to be, and are set apart as a public reservation, and shall hereafter be subject only to such rights as have been heretofore legally acquired under settlements, entries, reservations, or other forms of appropriation, and are now existing, but shall not be subject at any time to any other claim, use, or occupation, except for public highways; and any patent issued for any legal subdivision affected by this reservation under any claim hereafter initiated, shall contain a recital that it is issued subject to this proclamation.

In witness whereof, I have hereunto set my hand and caused the seal of the United States to be affixed.

Done at the City of Washington this 15th day of June, in the year of our Lord one thousand nine hundred and eight, and of the Independence of the United States the one hundred and thirty-second.

THEODORE ROOSEVELT.

(SEAL)

By the President:
ELIHU ROOT, *Secretary of State.*

(No. 1196)

Whereas, the customs and immigration laws of the United States can be better enforced and the public welfare thereby advanced by the retention in the Federal Government of complete control of the use and occupation of lands abutting on International Boundary Lines;

Now, therefore, I, William Howard Taft, President of the United States, do hereby declare, proclaim, and make known that there are hereby reserved from entry, settlement, or other form of appropriation and disposition under the public-land laws, and set apart as a public reservation, all public lands lying within sixty feet of the boundary line between the United States and the Dominion of Canada.

Excepting from the force and effect of this proclamation all lands which were prior to June fifteenth, nineteen hundred and eight, embraced in any legal entry or covered by any lawful filing, selection, or right of way duly of record in the proper United States land office or upon which any valid settlement had been made pursuant to law, the statutory period within which to make or complete entry of filing of record had not expired, and which has been or may be perfected as required by law. Any claims lawfully initiated between June fifteenth, nineteen hundred and eight, and the date hereof, lawfully maintained and perfected, may be patented subject to the reservation prescribed in proclamation of the President dated June fifteenth, nineteen hundred and eight.

In witness whereof, I have hereunto set my hand and caused the seal of the United States to be affixed.

Done at the city of Washington, this third day of May, in the year of our Lord one thousand nine hundred and twelve, and of the Independence of the United States the one hundred and thirty-sixth.

WM. H. TAFT.

(SEAL)

By the President:
HUNTINGTON WILSON, *Acting Secretary of State.*

RESERVATIONS BY THE PROVINCE OF BRITISH COLUMBIA

His Honour the Lieutenant-Governor of British Columbia, by and with the advice of his Executive Council, doth order as follows:

That all unalienated Crown lands within the Province of British Columbia lying within sixty feet of the 49th parallel of north latitude which is the boundary line between the United

States of America and the Dominion of Canada; and also all unalienated Crown lands lying within sixty feet of the boundary line between the Province of British Columbia and Alaska, be reserved for Government purposes.

A. Campbell Reddie,
Deputy Clerk,
Executive Council.

Approved and ordered
this 5th day of November,
a.d. 1908.

James Dunsmuir,
Lieutenant-Governor.

TREATY BETWEEN CANADA AND THE UNITED STATES OF AMERICA TO DEFINE MORE ACCURATELY AND TO COMPLETE THE INTERNATIONAL BOUNDARY BETWEEN THE TWO COUNTRIES

Signed at Washington, February 24, 1925

(Ratifications exchanged at Washington, July 17, 1925)

His Majesty the King of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas, Emperor of India, in respect of the Dominion of Canada, and the United States of America, desiring to define more accurately at certain points and to complete the international boundary between the United States and Canada and to maintain the demarcation of that boundary, have resolved to conclude a treaty for these purposes, and to that end have appointed as their respective plenipotentiaries:

His Britannic Majesty, in respect of the Dominion of Canada: The Honourable Ernest Lapointe, K.C., a member of His Majesty's Privy Council for Canada and Minister of Justice in the Government of that Dominion; and

The President of the United States of America: Charles Evans Hughes, Secretary of State of the United States;

Who, after having communicated to each other their respective full powers, which were found to be in due and proper form, have agreed to and concluded the following articles:

Article I

Whereas Article V of the Treaty concerning the boundary between the Dominion of Canada and the United States concluded on April 11, 1908, between Great Britain and the United States, provided for the survey and demarcation of the international boundary line between the Dominion of Canada and the United States from the mouth of Pigeon River, at the western shore of Lake Superior, to the north-westernmost point of Lake of the Woods, as defined by the treaties concluded between Great Britain and the United States on September 3, 1783, and August 9, 1842;

And whereas Article VI of the said Treaty concluded on April 11, 1908, provided for the relocation and repair of lost or damaged monuments and for the establishment of additional monuments and boundary marks along the course of the international boundary between the Dominion of Canada and the United States from the north-westernmost point of Lake of the Woods to the summit of the Rocky Mountains, as established under existing treaties and surveyed, charted, and monumented by the Joint Commission appointed for that purpose by joint action of the Contracting Parties in 1872;

And whereas it has been found by surveys executed under the direction of the Commissioners appointed pursuant to the said Treaty of April 11, 1908, that the boundary line between the Dominion of Canada and the United States from the mouth of the Pigeon River, at the western shore of Lake Superior, to the north-westernmost point of Lake of the Woods as defined by the treaties concluded on September 3, 1783, and August 9, 1842, is intersected by the boundary from the north-westernmost point of Lake of the Woods to the summit of the Rocky Mountains as established under existing treaties and surveyed, charted, and monumented by the Joint Commission appointed for that purpose in 1872, at five points in Lake of the Woods adjacent to and directly south of the said north-westernmost point, and that there are two small areas of United States waters in Lake of the Woods, comprising a total area of two and one-half acres, entirely surrounded by Canadian waters;

And whereas no permanent monuments were ever erected on these boundary lines north of the most southerly of these points of intersection;

The Contracting Parties, in order to provide for a more practical definition of the boundary between the Dominion of Canada and the United States in Lake of the Woods, hereby agree that this most southerly point of intersection, being in latitude 49° 23′ 04″·49 north and longitude 95° 09′ 11″·61 west, shall be the terminus of the boundary line heretofore referred to as the international boundary line between the Dominion of Canada and the United States from the mouth of Pigeon River, at the western shore of Lake Superior, to the north-westernmost point of Lake of the Woods and the initial point of the boundary line heretofore referred to as the international boundary between the Dominion of Canada and the United States from the north-westernmost point of Lake of the Woods to the summit of the Rocky Mountains, in lieu of the said north-westernmost point.

The aforesaid most southerly point shall be located and monumented by the Commissioners appointed under the said Treaty of April 11, 1908, and shall be marked by them on the chart or charts prepared in accordance with the provisions of Articles V and VI of the said Treaty, and a detailed account of the work done by the Commissioners in locating said point, together with a description of the character and location of the several monuments erected, shall be included in the report or reports prepared pursuant to the said Articles.

The point so defined and monumented shall be taken and deemed to be the terminus of the boundary line heretofore referred to as the international boundary line between the Dominion of Canada and the United States, from the mouth of Pigeon River, at the western shore of Lake Superior to the north-westernmost point of Lake of the Woods and the initial point of the boundary line heretofore referred to as the international boundary between the Dominion of Canada and the United States from the north-westernmost point of Lake of the Woods to the summit of the Rocky Mountains.

Article II

Whereas Article VI of the Treaty concerning the boundary between the Dominion of Canada and the United States concluded on April 11, 1908, between Great Britain and the United States provided for the relocation and repair of lost or damaged monuments and for the establishment of additional monuments and boundary marks along the courses of the international boundary between the Dominion of Canada and the United States from the north-westernmost point of Lake of the Woods south to the 49th parallel of north latitude and thence westward along said parallel of latitude to the summit of the Rocky Mountains, as established under existing treaties and surveyed, charted, and monumented by the Joint Commission appointed for that purpose by joint action of the Contracting Parties in 1872;

And whereas Article VI of the said Treaty concluded on April 11, 1908, further provides that in carrying out the provisions of that article the agreement stated in the protocol of the final meeting of the said Joint Commission, dated May 29, 1876, should be observed, by which protocol it was agreed that in the intervals between the monuments along the 49th parallel of north latitude the boundary line has the curvature of a parallel of 49° north latitude;

And whereas the Commissioners appointed and acting under the provisions of Article VI of the said Treaty of 1908 have marked the boundary line wherever necessary in the intervals between the original monuments established by the said Joint Commission, appointed in 1872, in accordance with the agreement stated in the Protocol of the final meeting, dated May 29, 1876, of the Joint Commission aforesaid, and as set forth in Article VI of the Treaty of 1908, by placing intermediate monuments on lines joining the original monuments, which have in each case the curvature of a parallel of 49° north latitude;

And whereas the average distance between adjacent monuments as thus established or re-established along the 49th parallel of north latitude from Lake of the Woods to the summit of the Rocky Mountains by the Commissioners acting under Article VI of the Treaty of 1908 is one and one-third miles and therefore the deviation of the curve of the 49th parallel from a straight or right line joining adjacent monuments is, for this average distance between monuments, only one-third of a foot, and in no case does the actual deviation exceed one and eight-tenths feet;

And whereas it is impracticable to determine the course of a line having the curvature of a parallel of 49° north latitude on the ground between the adjacent monuments which have been established or re-established by the Commissioners and the demarcation of the boundary would be more thoroughly effective if the line between adjacent monuments be defined as a straight or right line;

And whereas it is desirable that the boundary at any point between adjacent monuments may be conveniently ascertainable on the ground, the Contracting Parties, in order to complete and render thoroughly effective the demarcation of the boundary between the Dominion of Canada and the United States from the north-westernmost point of Lake of the Woods to the summit of the Rocky Mountains, hereby agree that the line heretofore referred to as the international boundary between the Dominion of Canada and the United States from the north-westernmost point of Lake of the Woods to the summit of the Rocky Mountains, shall be defined as consisting of a series of right or straight lines joining adjacent monuments as now established or re-established and as now laid down on charts by the Commissioners acting under Article VI of the Treaty of 1908, in lieu of the definition set forth in the agreement of the aforesaid Joint Commissioners, dated May 29, 1876, and quoted in Article VI of the said Treaty of 1908, that in the intervals between the monuments the line has the curvature of the parallel of 49° north latitude.

Article III

Whereas the Treaty concluded on May 21, 1910, between Great Britain and the United States, defined the international boundary line between the Dominion of Canada and the United States from a point in Passamaquoddy Bay lying between Treat Island and Friar Head to the middle of Grand Manan Channel and provided that the location of the line so defined should be laid down and marked by the Commissioners appointed under the Treaty of April 11, 1908;

And whereas it has been found by the surveys executed pursuant to the said Treaty of May 21, 1910, that the terminus of the boundary line defined by said Treaty at the middle of Grand Manan Channel is less than three nautical miles distant both from the shore line of Grand Manan Island in the Dominion of Canada and from the shore line of the State of Maine in the United States, and that there is a small zone of waters of controvertible jurisdiction in Grand Manan Channel between said terminus and the High Seas;

The Contracting Parties, in order completely to define the boundary line between the Dominion of Canada and the United States in the Grand Manan Channel, hereby agree that an additional course shall be extended from the terminus of the boundary line defined by the said Treaty of May 21, 1910, south 34° 42′ west, for a distance of two thousand three hundred eighty-three (2,383) metres, through the middle of Grand Manan Channel, to the High Seas.

The course so defined shall be located and marked by the Commissioners appointed under the Treaty of April 11, 1908, and shall be laid down by them on the chart or charts adopted in accordance with the provisions of Article I of the said Treaty, and a detailed account of the work done by the Commissioners in locating and marking said line, together with a description of the several monuments erected, shall be included in the report or reports prepared pursuant to Article I of the Treaty of April 11, 1908.

The course so defined and laid down shall be taken and deemed to be the boundary line between the Dominion of Canada and the United States in Grand Manan Channel from the terminus of the boundary line as defined by the Treaty of May 21, 1910, to the High Seas.

Article IV

Whereas, pursuant to existing treaties between Great Britain and the United States, a survey and effective demarcation of the boundary line between the Dominion of Canada and the United States through the Great Lakes and the St. Lawrence River and through the Straits of Georgia, Haro, and

Juan de Fuca from the 49th parallel to the Pacific Ocean and between the Dominion of Canada and Alaska from the Arctic Ocean to Mount St. Elias have been made and the signed joint maps and reports in respect thereto have been filed with the two Governments;

And whereas a survey and effective demarcation of the boundary line between the Dominion of Canada and the United States from the Gulf of Georgia to Lake Superior and from the St. Lawrence River to the Atlantic Ocean and between the Dominion of Canada and Alaska from Mount St. Elias to Cape Muzon are nearing completion;

And whereas boundary monuments deteriorate and at times are destroyed or damaged; and boundary vistas become closed by the growth of timber;

And whereas changing conditions require from time to time that the boundary be marked more precisely and plainly by the establishment of additional monuments or the relocation of existing monuments;

The Contracting Parties, in order to provide for the maintenance of an effective boundary line between the Dominion of Canada and the United States and between the Dominion of Canada and Alaska, as established or to be established, and for the determination of the location of any point thereof, which may become necessary in the settlement of any question that may arise between the two Governments, hereby agree that the Commissioners appointed under the provisions of the Treaty of April 11, 1908, are hereby jointly empowered and directed: to inspect the various sections of the boundary line between the Dominion of Canada and the United States and between the Dominion of Canada and Alaska at such times as they shall deem necessary; to repair all damaged monuments and buoys; to relocate and rebuild monuments which have been destroyed; to keep the boundary vistas open; to move boundary monuments to new sites and establish such additional monuments and buoys as they shall deem desirable; to maintain at all times an effective boundary line between the Dominion of Canada and the United States and between the Dominion of Canada and Alaska, as defined by the present treaty and treaties heretofore concluded, or hereafter to be concluded; and to determine the location of any point of the boundary line which may become necessary in the settlement of any question that may arise between the two Governments.

The said Commissioners shall submit to their respective Governments from time to time, at least once in every calendar year, a joint report containing a statement of the inspections made, the monuments and buoys repaired, relocated, rebuilt, moved, and established, and the mileage and location of vistas opened, and shall submit with their reports, plats and tables certified and signed by the Commissioners, giving the locations and geodetic positions of all monuments moved and all additional monuments established within the year, and such other information as may be necessary to keep the boundary maps and records accurately revised.

After the completion of the survey and demarcation of the boundary line between the Dominion of Canada and the United States from the Gulf of Georgia to Lake Superior and from the St. Lawrence River to the Atlantic Ocean, as provided for by the Treaty of April 11, 1908, the Commissioners appointed under the provisions of that Treaty shall continue to carry out the provisions of this Article, and, upon the death, resignation, or other disability of either of them, the Party on whose side the vacancy occurs shall appoint an Expert Geographer or Surveyor as Commissioner, who shall have the same powers and duties in respect to carrying out the provisions of this Article, as are conferred by this Article upon the Commissioner appointed under the provisions of the said Treaty of 1908.

The Contracting Parties further agree that each Government shall pay the salaries and expenses of its own commissioner and his assistants, and that the expenses jointly incurred by the Commissioners in maintaining the demarcation of the boundary line in accordance with the provisions of this Article shall be borne equally by the two Governments.

ARTICLE V

This treaty shall be ratified by the Contracting Parties and the ratifications shall be exchanged in Ottawa or Washington as soon as practicable. The treaty shall take effect on the date of the exchange of ratifications.

Upon the expiration of six years from the date of the exchange of ratifications of the present treaty, or any time thereafter, Article IV may be terminated upon twelve months' written notice given by either Contracting Party to the other, and following such termination the Commissioners therein mentioned and their successors shall cease to perform the functions thereby prescribed.

In faith whereof, the respective Plenipotentiaries have signed this treaty in duplicate and have hereunto affixed their seals.

Done at Washington the 24th day of February, A.D. 1925.

(L.S.) ERNEST LAPOINTE.
(L.S.) CHARLES EVANS HUGHES.

CONTENTS

ILLUSTRATIONS

MAPS AND DRAWINGS

The party left the field on October 16 and returned to Wrangell, and thence to Vancouver.

The personnel of the party was as follows: engineer in charge, A. J. Brabazon, D.L.S.; assistants, D. V. Ritchie, A. G. Gillespie, C. H. Brabazon, T. P. Reilly; and 8 hands. The United States representative was J. M. Donn.

United States Party on Unuk River

Travelling by the steamer *Alaskan* from Ketchikan, the party arrived at the mouth of Unuk River on the evening of May 16, and on the following morning a gasoline launch towed their loaded boats to the dock of the Unuk River Mining and Trading Company. It was expected that transportation to the boundary would be comparatively easy as the Mining Company was building a road from the mouth of the river to their mine several miles beyond the boundary. However, it was found that, although the road was nearly completed as far as the boundary, the company had not sufficient horses and wagons to forward their own supplies and those of the survey party as well. As river navigation was found to be impracticable because of the swift current and the numerous log jams, back-packing was the only means of transportation until June 30 when the Mining Company, having obtained additional teams, began to haul the remainder of the outfit of the party forward from the landing.

In the meantime a base line was measured on the tide flats at the head of Burroughs Bay, from which triangulation was extended to connect with several old stations of the United States Coast and Geodetic Survey, which were recovered there. The triangulation was then carried up the river as far as the boundary to control the topography and to determine the positions of the boundary peaks and monuments.

Good progress was made in spite of considerable delay caused by forest fires and spring freshets, both the results of unusually fine weather; the freshets flooded the camp and washed out several sections of the newly constructed road, and the fire burned the large bridge across Blue River.

Late in July the main camp was made about 25 miles above the mouth of the river and one-half mile below the boundary, and operations were carried on in the boundary area. A fly camp was pitched at timber-line on the slope of Boundary Peak 40 (Mount Stoeckl), from which the peak was climbed on August 15. A signal was erected there in a blinding snowstorm. On account of continued bad weather no further work could be done until August 23. At this time the engineer in charge accompanied by the Canadian representative identified several boundary peaks, among which was one thought to be Boundary Peak 28, which will be referred to later.

Boundary Peaks 23 (Mount Willibert), 24 (Mount Blaine), the assumed 28, and 47 (Mount Lewis Cass) were tied in to the triangulation by intersection, and in addition to the phototopographic work a considerable amount of plane-table work was executed in the vicinity of the boundary line. The boundary vista was cut down the south side of Boundary Peak 40 (Mount Stoeckl) and over the tops

Monument at Boundary Point 39, Unuk River region.

of the ridges between Unuk River and Boulder Creek, and in this section six aluminium-bronze monuments were set: a cone on the summit of Boundary Peak 40; No. 39, a cone at timber-line on the south slope; No. 38, an obelisk on the north side of the river; No. 37, a cone on the south side of the river; No. 36, a cone on the crest of the first ridge south of the river; and No. 35, a cone on the crest of the second ridge. It had been intended that one of the obelisks should be put on the south bank of the river, but it was lost when the canoe carrying it across capsized.

In the meantime a sub-party continued the triangulation and phototopography southward from a camp at timber-line above the head of Lake Creek, a tributary of Unuk River. The last of their observations were made on September 7, which is late in the season on the high mountains as each passing storm leaves new snow on the peaks, and a heavy snowfall means a complete blocking of further mountain work. The sub-party then joined the main party at work on the vista.

On September 22 the Mining Company's teams started moving the outfit of the party down the river. As the gasoline launch, which made weekly trips between Ketchikan and the mouth of the Unuk, was too small to accommodate the party, a steamer was chartered for their transportation back to Ketchikan. Passage for Seattle was taken on the steamer *Humbolt,* which left Ketchikan on October 9.

It has already been stated that Boundary Peak 28 was identified from Boundary Peak 40, and that a part of the boundary line was marked between the two peaks. However, when computations were made from the field notes after the close of the survey, it was found that the peak identified as Boundary Peak 28 was really Boundary Peak 18. Actually there was no prominent peak on the snow-covered ridge located in the position of Boundary Peak 28 as shown on the Award map; but there was such a peak some 5 miles farther inland, and on the photographs supplied for identification purposes this peak was marked as Boundary Peak 28; furthermore, Boundary Peak 18, visible behind the snow-covered ridge, resembled the peak marked as Boundary Peak 28 on the photographs. Had the triangulation been finished sooner and the results computed in the field, these facts would have been discovered and the line would have been left unmarked until its location had been decided upon by the commissioners. As it was the commissioners agreed that the line as marked across the Unuk Valley should be retained and that Boundary Point 28 should be the highest part of the snow-covered ridge of Mount Middleton on the direct line between Boundary Peaks 40 and 18.

The personnel of the party was: engineer in charge, Fremont Morse; assistants, L. Netland and Adolf Mosheim; and 12 hands. The Canadian representative was J. D. Craig, D.L.S.

Canadian Party on Salmon River

Arrangements were made in Victoria with the Canadian Pacific Steamship Company to transport the party to the head of Portland Canal on the steamship *Tees*, although the regular northern terminus of her run was Naas Harbour. Disembarking at Eagle Point on May 10 they pitched their first camp about a quarter mile above the mouth of Salmon River. Although the townsite of Stewart at the mouth of Bear River was in existence at that time, with a small floating population of miners, a mining-recorder's office, and a post office, there was no townsite at the mouth of Salmon River; the river flat was homesteaded, but the road up the valley had not yet been built.

For the first 2 weeks the river afforded a convenient route for transportation as the water was low, and although the stream was too swift to paddle against, the sand bars on either side gave good footing for tracking the boats and canoes. This mode of transport was abandoned when the heavy rainfall late in May and the extremely warm weather early in June melted the snow on the mountains and snow fields, and made travel impossible on the flooded river, which carried down-stream large numbers of uprooted trees and huge blocks of ice from the glaciers at its head. Trails were then cut up the valley and the supplies were packed in by the men.

The party had been instructed to survey the line northerly and northwesterly towards Unuk River, and if possible to make a connection with the United States party operating from there. Their first duty was the location of Boundary Point 7, the point D of the Award, defined by the commissioners as "the highest point on the 56th parallel of latitude between the waters flowing into the Bear River on one side and the Salmon River on the other". The 56th parallel for this purpose was determined by triangulation from the United States Coast and Geodetic astronomic stations at the head of Portland Canal.[1]

From the latter part of May until early in July, during the progress of the triangulation and phototopography up the Salmon Valley, supplies were being packed from a cache 5 miles above the mouth of the river over a trail cut by the party. The river was crossed at a point opposite the mouth of Texas Creek, about 12 miles above salt water, by means of a block running over a rope stretched between two tripods, one on each side of the river, and the trail was continued up the Texas Valley. The creek in turn was crossed by a boat attached to an overhead rope.

Early in July the river rose again, flooding the trails and destroying the rope crossings; they were rebuilt but still another flood destroyed the new trails and

[1] *See* footnote 1 on next page.

The sloughs leading from the Stikine to the Iskut were explored for a possible short cut that would avoid the swift water at the mouth of the Iskut; but the sloughs were still full of snow and were of no use until about 2 weeks later. On May 15 the first trip was made up the Iskut and a cache was established about 7 miles from its mouth; then another cache was established farther up the river. It took seven of these steps to get the main camp to the boundary area, each step taking about a week. The load to be moved each time increased rather than decreased, as the Indians in the meantime made three trips from Wrangell with provisions. About 25 miles from the Stikine, the South Fork of the Iskut joins the main stream, and another 10 miles or so up stream the South Fork is divided into two streams—that flowing from the southwesterly direction having its source, as before mentioned, on the United States side of the boundary. Approximately 5 miles above the latter fork the valley narrows down to a canyon, impassable for canoes for over a mile, around which a trail was cut and the canoes portaged. River navigation was then resumed for the final 6 miles to the boundary area.

In order to project the boundary line from Boundary Peak 48 to Boundary Peak 53 into and across the valley of the South Fork a fly camp was made on the ridge leading to Boundary Peak 48. The peak was climbed and a point on the line was located on a ridge immediately south of the river; from there it was produced into the valley. The work of cutting out the vista was started on July 22, and a small party was kept continuously at this work until the early part of October. Four conical aluminium-bronze monuments, Nos. 49 to 52, inclusive, were established in the valley.

The remainder of the party in the meantime had been engaged on triangulation and camera work, and by August 23 had secured sufficient data to map the country down as far as the main branch of the Iskut. After that date, however, the weather turned wet and cloudy and continued so until after the completion of the vista cutting on October 5.

By June 5 the Bradfield River sub-party had located their camp at the head of canoe navigation on the North Fork of the Bradfield. From this camp they re-occupied the camera stations of the previous year, as well as several new stations that overlooked the region southerly at the head of Blue River. Early in August they ascended the East Fork of the Bradfield to complete their phototopographic work. They then, early in September, returned to Wrangell and ascended Iskut River to join the main party.

The very unfavourable weather showing no signs of improvement upon the completion of the vista cutting, the whole party started down stream. They reached the Stikine on October 12, but owing to stormy weather did not reach Wrangell until 2 days later. Transportation south could not be obtained until October 21, when they sailed for Victoria.

The personnel of the party was: engineer in charge, J. D. Craig, D.L.S.; assistants, J. M. Bates, Robert Smith, and A. G. Stewart; and 13 hands. The United States representative was D. W. Eaton.

UNITED STATES PARTY ON THE TRIBUTARIES OF UNUK RIVER AND LEDUC RIVER

The season's work in this district was to be an extension of that of 1905 on Unuk River, southerly to Leduc River and northwesterly to the Blue River region. As the character of the topography between the head of Lake Creek, a southern tributary of Unuk River, and Leduc River was unknown, it was thought to be most practicable to reach the boundary area of the Leduc by ascending that stream as far as possible with boats and then back-packing for the remainder of the distance. Likewise the valley of Blue River, which flows into Unuk River 6 or 7 miles below the boundary, was very little known; the lower part of the valley was known to be filled with volcanic lava, but the difficulty of travelling had prevented much prospecting there. Therefore, as it was certain that transportation would be difficult, it was deemed advisable to send an advance party into the field early in May.

A party of twelve men arrived in Ketchikan on May 12. There they were met by a launch that carried them to the head of Burroughs Bay, where they established a temporary camp at the landing place of the Unuk River Mining and Trading Company. The provisions, which had been purchased in Seattle, had been packed in bags and boxes averaging 50 pounds, appropriately marked so as to require no breaking open of packages to distribute the contents; this greatly facilitated the work of sorting the outfits for the three sub-parties. The mining company furnished wagon transportation as far as "The Bluff", about 10 miles up the Unuk. The supplies for the Lake Creek party were left at a cabin about 5 miles from the landing, but those for the Blue River party had to be back-packed over "The Bluff", a distance of about 5 miles, to the mouth of that river.

One-half of the advance party had been assigned to work on Leduc River. On May 25 they left the landing in two 20-foot skiffs that had been built for the purpose. The remaining six men continued the work of transportation and looked for suitable travelling routes along Lake Creek and Blue River. On June 22 the second detachment of the field party arrived at the landing and the force on the Unuk was then divided into two parties, one to work on Lake Creek and the other on Blue River.

THE LEDUC RIVER PARTY

Leduc River, which lies approximately parallel with Unuk River and 15 miles south of it, has its source in a small glacier about 2 miles above the boundary and empties into Chickamin River some 12 miles above its mouth. The ascent of these two rivers was slow and arduous. Many of the bars were still covered with snow and the nights were decidedly cold. Brush and tree jams made frequent portages necessary, and the many rapids delayed progress owing to the necessity of using the entire party to manage a single boat, even when only partly loaded. About 8 miles below the boundary the Leduc became quite unnavigable and supplies were back-packed from that point to a camp site near the boundary. The ascent of Chickamin and Leduc Rivers took about 6 weeks, whereas half that time had been considered a reasonable estimate.

It was found to be impracticable to climb the precipitous northern slope of Boundary Peak 18, but Boundary Peak 23 was climbed and temporarily marked by a drill hole in the rock. The boundary line was projected from the latter peak southerly to Boundary Peak 18 and westerly to Boundary Peak 24. There was a considerable amount of timber on each side of Leduc River, but the vista through it would not have been difficult to cut had it not been for the steepness of the slopes. As it was, the work progressed slowly because of insecure footing and because much of the work had to be done in the heavy rain that prevailed for most of the season. At this time the boundary line could only be temporarily marked owing to a delay in the shipment of the monuments, which did not arrive at Ketchikan in time to be taken up the river.

Besides cutting the vista across the Leduc Valley, the party occupied Boundary Peaks 23 and 24 as camera stations. Another operation engaged in was the exploration of the country northwesterly to establish a route for communication with the Lake Creek party to obtain supplies. A stream that flows northward to Unuk River has its source in a glacier west of Boundary Peak 24; this stream was named Gracey Creek, after Hiram Gracey, a member of the party, who was probably the first white man to explore its upper reaches. Although this route was found to be practicable it was quite difficult and circuitous. It was necessary to descend to Gracey Creek and then climb to the divide between that stream and the east fork of Lake Creek. At this divide there is a series of lakes enclosed by very steep and crumbling slopes, around at least one of which it was necessary to pass. The largest was selected; it was called Smith Lake for W. F. Smith, the assistant in charge of the party, who made the first trip on this route when the lake was discovered. This lake is free of floating ice for only a short time in the late summer.

The working season came to an end about the middle of September, when new snow began to fall. As it was evident that work would be required in this area during another season the non-perishable part of the outfit was stored in Gracey Creek Valley. The party then made their way to the forks of Lake Creek and combined with the party there in packing and canoeing to the coast.

THE LAKE CREEK PARTY

Leaving Unuk River, Lake Creek is easily navigable with canoes for about 4 miles, although it is quite shallow in many places, until the falls are reached. The journey to these falls from the cabin where the provisions had been stored formed the first stage of the route to the boundary, the most troublesome part of which was the crossing of the swift Unuk River. A steep trail was opened around the falls and a portage was located to a point just above a narrow rocky gorge, at which point the canoes could be used to ascend the stream for another 3 miles, by "lining", until the stream became too swift and shallow for further canoe navigation. A temporary camp was established just below a rock-jam in the stream, and from there a trail was made for about 8 miles to "Lake Creek Forks" where the permanent camp was established.

The principal feature of the work of this party was to be the location of Boundary Point 28, which, as before stated, was to be on the straight line between Boundary Peaks 18 and 40, and on the flat snow-covered ridge about midway between them (*See* page 52). There was found to be, however, another high snow-covered ridge intervening between the boundary point ridge and Boundary Peak 40, over which it would be necessary to project the line; this was called "Net Ridge". But the line crossed Net Ridge at the crest of a steep snow slope where it was difficult to set up an instrument firmly, and as it also crossed the boundary point ridge on a long stretch of snow the projection of the line at any time would be exceedingly difficult; moreover, the weather was so bad that it was seldom that both terminal peaks were visible at the same time, and at each appearance of the sun the snow melted rapidly and constantly shifted the position of the instrument. In these circumstances it was found impossible to project the line accurately, and this part of the work had to be postponed for a more favourable season.

In addition to the attempted projection of the line, two stations were occupied with the topographic camera, and one with the theodolite for triangulation. Another triangulation station was selected and a signal was erected, but the weather did not permit any further observations. This party was also actively engaged from time to time with the transportation of supplies to the Leduc River party, and during the season made a trail from Lake Creek Forks up the east fork to Smith Lake.

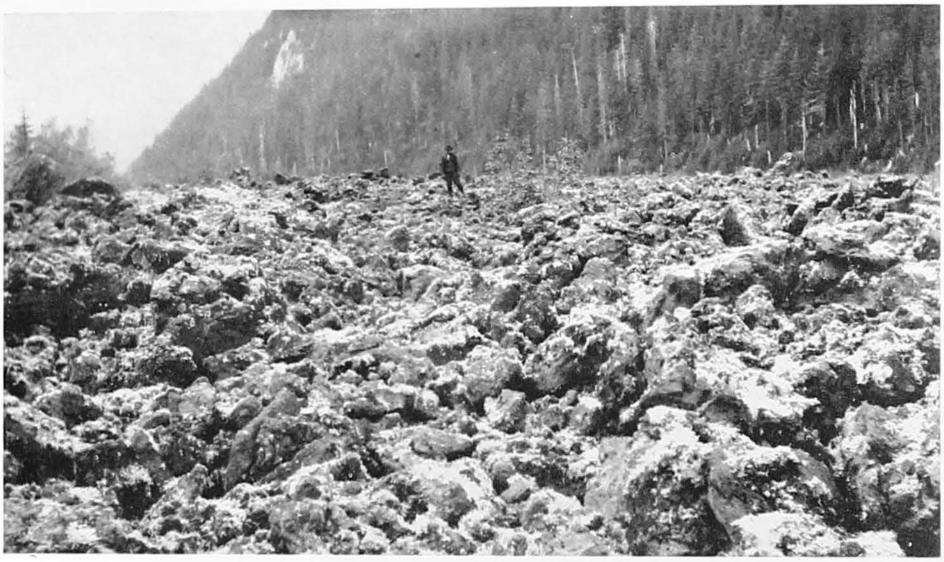
During the latter part of September and most of October the combined Lake Creek and Leduc River parties made their way down to Unuk River. At this time the weather was cold and the new snow made the work very disagreeable and dangerous.

THE BLUE RIVER PARTY

Blue River has its source in the snow fields south of Boundary Peak 47; thence it flows for some 15 miles southeasterly to Unuk River, which it joins 6 or 7 miles below the boundary. The two largest tributaries cross the boundary, the most easterly, the "Lava Fork", about 5 miles, and the "West Fork" a little over a mile, from the Blue.

Blue River Valley for the first 6 miles was found to be filled with volcanic lava of comparatively recent origin, making the surface exceedingly rough. Aside from the consequent slowness of travel, great inconvenience was caused by the rapid wearing out of footwear from the cutting action of the lava fragments; 1 or 2 days' travel making it necessary to repair new heavy boots. The roughness of the lava blocks prevented them from falling into stable positions and they rolled under the men's feet, causing a great many bad falls with severely cut hands. There had been two or three separate flows of the lava; one of them seemed to have had its origin, in part at least, only a few miles from the Unuk. It was found that the largest flow had been down the Lava Fork from its source about 2 miles above the boundary, between the Lava Fork and Canyon Creek. Some lava had also flowed down the valley of this latter stream. The mountain tops were strewn with cinders, and the trees along the edges of the lava stream had been killed by the heat.

The first camp on Blue River was pitched on the south side of the river, about 3 miles from its mouth, at the beginning of the narrow part of the valley. From there a trail was cut along the steep hillside to a point on the river where a 2-mile lake had been formed by a lava dam. A second camp was made on the lava near the upper end of a small timbered cinder cone about $1\frac{1}{2}$ miles below the Lava Fork.



Lava field in the valley of Blue River.

A mile above this camp a cache was made just above some open water where boating would not be necessary to reach the boundary. To cross the river, folding canvas boats were used, and although they were very slow as compared with ordinary canoes their greater portability made them more useful where they had to be packed for long distances.[1] Up the Lava Fork the trail followed the lava to the boundary line; this was the roughest and evidently the most recent of the lava flows. The final camp was made about one-half mile from the boundary.

A number of topographic stations were established and occupied during the season, and in the first half of August the line between Boundary Peaks 40 and 47 was located by the determination of a line point on a high snow dome about 1 mile west of Boundary Peak 40, from which it was possible to see both the boundary peaks. From this point the line was extended over the snow to the Albert Ridge between the Lava Fork and West Fork, and other similar points were established in the Lava Fork Valley. Some vista cutting was done across the valley, but about the middle of September it was found it would be impossible to complete the work. The three monuments that were to be set on the line were taken to their respective sites, but the setting of them was postponed until the following

[1] These were 14-foot "Acme" boats weighing about 80 pounds, which could be carried in two packs.

season in order that the line points might be verified. The non-perishable part of the outfit was placed in a cache, and towards the end of September the party started back to the Unuk.

Bears shot near boundary on Blue River.

Owing to the great difficulties encountered from the new snow and high water, the combined parties did not reach the mouth of the Unuk until the latter part of October.

Great and unforeseen difficulties encountered in a hitherto unknown country, together with an exceptionally rainy season, prevented the completion of the work in this district; but a good start was made and the routes of transportation were well established for continuation of the work the following season.

The personnel of the party was: engineer in charge, O. M. Leland; assistants, S. L. Boothroyd, G. I. Gavett, and W. F. Smith; and 17 hands. The Canadian representative was F. H. Mackie, D.L.S.

SEASON OF 1909—EAST OF ENDICOTT ARM, ISKUT RIVER, LEDUC RIVER, AND THE TRIBUTARIES OF UNUK RIVER

The field work of 1909 was in its entirety a continuation of the unfinished surveys of the previous year. Two Canadian parties were organized to return, respectively, to the boundary area east of Endicott Arm and to Iskut River, and likewise a United States party was organized to reascend the tributaries of Unuk River and to complete the work at the head of Leduc River.

In the spring of this year His Britannic Majesty's Commissioner placed the direction of the Canadian parties in the hands of Mr. Noel J. Ogilvie, D.L.S., previously engaged on the 49th Parallel in British Columbia; this position was held by Mr. Ogilvie until the completion of the field work of 1914.

with that of 1904 on Stikine River. Early in August a canoe load of supplies was lost on the Iskut; one Indian was towing the canoe and another was in it, steering, when it fouled a partly submerged snag. Towards the end of September the river had risen very high and the snow line was creeping lower each day. Hoping to complete the triangulation to the Stikine the party stayed on, but as the bad weather continued they returned to the mouth of the Iskut on October 1. It then rained continuously until October 7. Early the next day the engineer in charge started for Wrangell in a canoe and, assisted by wind and tide, arrived there early in the afternoon. A launch was chartered to bring the party and outfit from the mouth of the Iskut and on October 17 they returned to Vancouver.

The work of this party completed the survey of Iskut River. Although the triangulation was not completed to the Stikine, the geographic control for this area was provided by the position of Boundary Peak 53, obtained from the Stikine River work of 1904, and Boundary Peak 48, from the Bradfield River work of 1907.

The personnel of the party was: engineer in charge, F. H. Mackie, D.L.S.; assistant, J. M. Bates; and 8 hands.

United States Party on the Tributaries of Unuk River and on Leduc River

The party reassembled at the mouth of Unuk River on May 8. There it was divided into three sub-parties to work on Leduc River, Blue River, and Lake Creek. Transportation was again facilitated by the use of the teams and wagons of the Unuk River Mining and Trading Company; but considerable work was necessary to clear the road of windfalls and to repair bridges. Owing to the difficulties of navigation encountered on Leduc River during the previous year it was planned that the Leduc River party should reach their field of operations by way of Lake Creek; so, while the Blue River party continued up the Unuk, the combined Lake Creek and Leduc River parties made their first camp at the log cabin a mile below the mouth of Lake Creek.

A temporary camp was made by the two parties at the old site above the Lake Creek falls on May 26, and from this camp as a base they transported their outfits and supplies from the log cabin to the forks of Lake Creek, where the permanent camp for the Lake Creek region was again established. Upon completion of the transportation, on June 24, the Leduc River party continued with the packing of their equipment up the east fork of Lake Creek to the old Gracey Creek camp site, and the Lake Creek party commenced their work in the vicinity of Turning Point 28.

LAKE CREEK

The work on Lake Creek included the reoccupation of the old triangulation stations, the location of the line from the Unuk Valley to Turning Point 28, and the marking of the boundary line by a vista and several monuments. Bad weather again caused delays in all of the work that involved observing. The extension of the line to Turning Point 28 was attended with a continuation of the difficulties that made its completion impossible the previous year. In addition, as the season was more backward than usual, the signal on Boundary Peak 40 was obscured for a long time by a deep bank of snow just east of it. Finally, however, on August 9 Boundary Peaks 18 and 40 were both visible. The assistant in charge of the Lake Creek party placed himself on the snow-covered "Net Ridge" of 1908 and lined himself in with the theodolite on the true line between Boundary Peaks 18 and 40. From his point on line he then lined in the assistant in charge of the Leduc River party on the snow-covered slope of Mount Middleton, placing him on the true line between Boundary Peaks 18 and 40. The true line as thus established on Mount Middleton was then projected toward Boundary Peak 18 until it reached an outcrop of rock on which it could be permanently marked. A point on this outcrop was assumed by the engineer in charge to be a satisfactory position for Boundary Point 28.

Late in August the party was rejoined by the Leduc River party. The vista across the west fork of Lake Creek was then completed and two copper bolts were placed to mark the boundary, one on each side of the creek. A conical monument was also placed on the rock outcrop mentioned above to mark Boundary Point 28. But this location proved to be unsatisfactory to the commissioners, as it did not conform to their decision of 1905 regarding the point in question. As will be seen in the narrative for 1920, the monument was removed and Boundary Point 28 was shifted northwestward to the crest of Mount Middleton ridge on the line between Boundary Peaks 18 and 40.

LEDUC RIVER

After the experiences of the previous year in packing on the steep slopes around Smith Lake, a folding canvas boat was provided for crossing the lake, but owing to the backwardness of this season the lake was still covered with ice at the end of June. The snow on the slopes, however, being solid enough to support a foot-path, most of the packing around the lake was completed before it melted away. A camp was then established above the glacier at the head of Gracey Creek.

Monument at Boundary Point 22, Leduc River.

As the vista across Leduc River had been completed during the previous season it only remained to erect the monuments there, which was done from a fly camp with the smallest possible outfit. Using the Gracey Creek camp as a base the party back-packed the supplies over the divide to the Clarasmith Glacier, constructing a sledge to facilitate transportation over it. Boundary Peak 23 was occupied to put the monuments on the line to Boundary Peak 18. Two conical monuments, Nos. 21 and 22, were erected, and the line was further marked by two copper bolts, one on each side of the river. These monuments and bolts were connected with the triangulation and several camera stations were occupied in this area. While this work was in progress there was continuous rain for 10 days.

GRACEY CREEK

The Leduc River party returned to the Gracey Creek camp on August 12. Although the growth of timber here was not heavy they found it difficult to cut on the steep slopes. A monument was placed above the glacier on the east side of the valley and a copper bolt on top of a bluff on the west side. This line, however, was altered in 1920 owing to the change in the final point selected by the commissioners to mark the position of Boundary Point 28.

Upon the completion of their work in Gracey Creek Valley, on August 24, the party moved to the west fork of Lake Creek where they joined the Lake Creek party. The Lake Creek line was finished on September 8 and 3 days later the entire outfit of the two parties had collected at the forks for transportation to Unuk River. A long rainy period followed, the creek was flooded and the difficulties of transportation were increased so much that Unuk River was not reached until October 4. The combined parties then went up to Blue River to assist the party there with cutting the vista on the West Fork.

BLUE RIVER

As already stated, the Blue River party continued up Unuk River when the other parties went up Lake Creek in the latter part of May. A team was taken around "The Bluff" and used to haul the supplies and outfit to the mouth of Blue River. A temporary camp was made near the mouth of the Blue, and as the water was exceptionally low at this time the old camp below the Lava Fork could be reached without leaving the lava; this was easier than packing over the

Camp on lava bed of Blue River.

mountain trail on the southwest side of the valley. The final camp was established at the old site on the Lava Fork at the end of June.

The vista cutting was then resumed on the steep valley slopes; there the timber was mostly hemlock, the largest trees being about $2\frac{1}{2}$ feet in diameter. The cutting was completed on September 5. In the meantime the line between Boundary Peaks 40 and 47 was retraced, Monument 42 was erected at the lower end of the vista on the east side of the river and a copper bolt was embedded in the rock at the upper end; on the west side of the river Monument 43 was erected high up on the Albert Ridge and a copper bolt was embedded on the crest of the same ridge. The first of these bolts was replaced in 1920 by Monument 41 and the latter by Monument 44.

Above the mouth of the Lava Fork on Blue River, Blue Lake extends for 2 miles between steep mountain sides. This lake was formed when the flow of lava filled the river valley below it. A canoe was used on the lake and upper river to reach the work on the West Fork of Blue River.

A camp was established near the southeast end of Blue Lake from which an observing party occupied several triangulation and camera stations. This camp also served as a base for the work on the West Fork, which was started on September 7. Although it was estimated that with the assistance of the party from Lake Creek, the vista across the West Fork Valley would be completed in 2 weeks' time, owing to the late arrival of that party, on October 10, and the very bad weather, cutting was discontinued on October 15 before being completed. Monument 46 was erected on the west side of the valley and Monument 45 was taken to its site on the bluff on the east side, but because of the deep snow it was not set up; later, in 1920, it was erected by the party working in that region.

Returning to the mouth of Unuk River the whole party was assembled at the landing by October 27—a team having been secured to haul their equipment down from The Bluff. The entire party did not reach Ketchikan until November 5, well soaked by the persistent rain and snow. There a warehouse was utilized for drying and packing the outfit. They left Ketchikan for Seattle on November 8.

The work of this party virtually completed the boundary delimitation on Leduc River and on Unuk River and its tributaries. Subsequently, mining developments between Unuk and Salmon Rivers called for further work in the locality, which was done in 1920.

The personnel of the party was: engineer in charge, O. M. Leland; assistants, S. L. Boothroyd, G. I. Gavett, and Jesse Hill; and 23 hands. The Canadian representative was T. H. G. Clunn, D.L.S.

SEASON OF 1910—TSIRKU RIVER, CHILKAT RIVER, TALLSAYKWAY RIVER, AND SALMON RIVER

During the season of 1910 one United States party and three Canadian parties worked in various districts. The United States party ascended Tsirku River and, occupying the peaks southerly to Boundary Peak 157, made direct

United States Party on Unuk River and Its Tributaries

Immediately following the meeting of the Commissioners in March the United States Commissioner communicated with the officers of the Forest Service in Ketchikan, and through them purchased 5,500 pounds of provisions for the use of the Unuk River party. He also made a contract with two experienced packers, who were to deliver these provisions at the boundary, some 30 miles from the mouth of the river, and return to Ketchikan by May 18 for the party, with whom they agreed to work during the field season. The packers were supplied with a Yukon poling boat, built to their specifications in Ketchikan. With one man and an Eskimo dog on the tow line and two men in the boat with poles, they relayed the provisions up the river to a cache near the boundary in 17 days.

Lining poling boat up Unuk River.

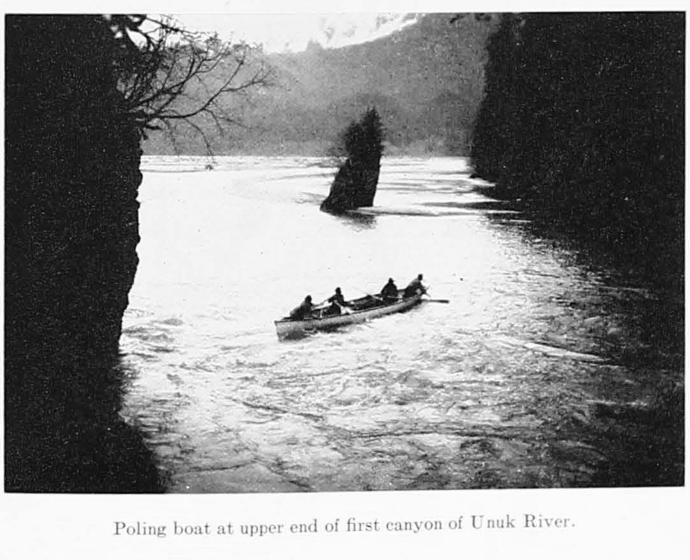
The party was organized in Seattle, where an 18-foot Oldtown canoe, a 13-foot King canvas folding boat, sail-silk tents, and further provisions were purchased. They arrived in Ketchikan on May 13, and 4 days later established camp in the abandoned storehouse of the Unuk River Mining and Transportation Company. An attempt was made to reach the boundary by the old mining road; but bridges had been washed out, fills around the rocky bluffs had caved in, and the snow was too deep in the woods for effective trail making. Consequently, the whole party made their way up the river, with their supplies and equipment, in the poling boat. They stopped at four camps en route, and the journey was made in relays, two trips between each camp. Great difficulty was experienced in passing through the canyon where Blue River enters the Unuk. In the last 500 feet of this canyon there was a vicious cross current with eddies on each side. After a struggle with the swift current the boat was got to a small island upstream. There a rope was tied to a tree and the supplies were ferried up to it by alternately allowing the boat to drift downstream and hauling it up again hand over hand. On June 1 the last boat load was taken from the fourth camp to the cache near the boundary.

It had been believed that the vista on the southeast side of Unuk River had been completely cut in 1905, but it was found that this was not so. Most of June was spent clearing this vista, which proved to be difficult work through the heavy timber on the steep slopes. During this time an attempt was made to get a trail up Boulder Creek and across the divide to Gracey Creek, but the attempt was abandoned as impracticable.

On June 30, the engineer in charge left camp early in the morning and arrived at the mouth of the river in the afternoon. He was accompanied by the two packers and their assistant who had decided to leave the party, and by a member of the party who was suffering from appendicitis. They were taken to Ketchikan by launch on the following day. While there, the poling boat was overhauled and a frame was put on the stern for attaching an Evinrude motor. On July 12, with four new men, the engineer in charge returned to Unuk River, which was by this time in flood. By using oars and motor they reached the foot of the canyon on July 15, but upon resuming their voyage upstream the next morning they could make no headway against the swift current, so they again resorted to their 500 feet of tow line. Two men went ahead with the line and from a convenient spot let one end downstream attached to a float, which was picked up by the men in the boat. The line was then tied to a tree to which the men hauled their boat, using the motor to keep it away from the shore. By continually repeating this operation it took them 2 days to ascend the 1-mile length of the canyon.

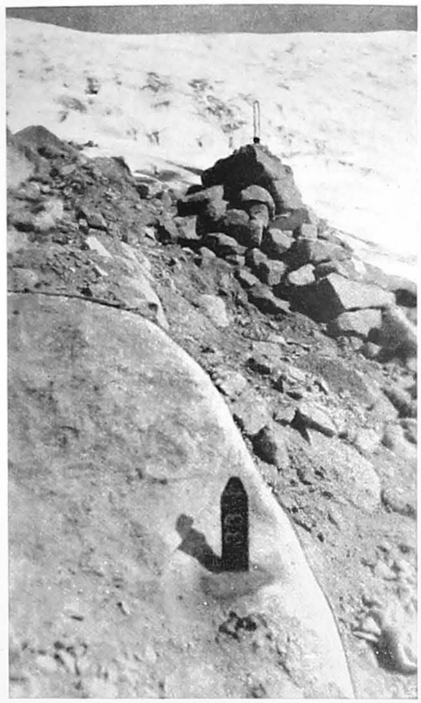
Vista on the south side of Unuk River. The crest is about 1,200 feet above the river bed.

In the meantime a base line had been measured on the bars of Unuk River near the main camp, Monument 34 was set, and this monument, together with Nos. 35 to 38 inclusive, set in 1905, was tied in to the triangulation; during that time also the Canadian representative started phototopographic work between Unuk River and Boulder Creek.



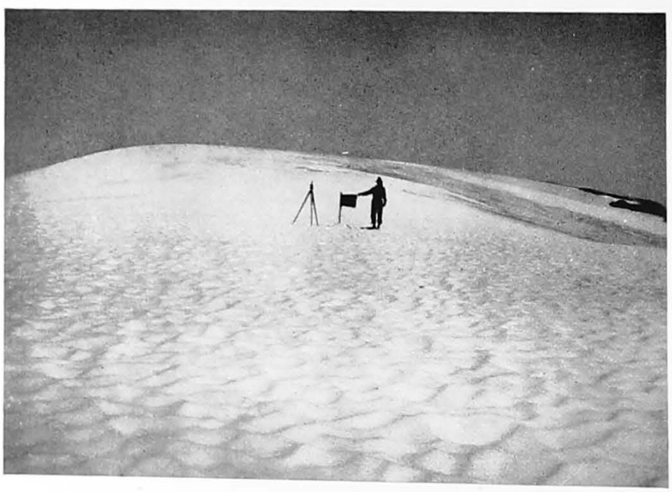
Poling boat at upper end of first canyon of Unuk River.

Operations were delayed early in August by heavy rains and floods, but on August 7 the floods began to subside. The triangulation and monument-setting party then crossed the Net Ridge to Lake Creek, from where they resumed the work of 1909. On the line between Boundary Points 40 (Mount Stoeckl) and 18 (Mount John Jay), a point on Net Ridge marked by a pole and cairn during that year was recovered and used for the selection of a site for Monument 32. From this monument the vista was reopened in both directions. On the northwesterly side of the ridge Monument 33 was set on the highest rock ledge crossed by the line. Southeasterly, Monument 29 was set just below the snow field on Mount Middleton, Monument 30 was set on the east side of Lake Creek by removing the bolt set in 1909 and drilling a larger hole, and Monument 31 was set 0·051 metre southeasterly along the line from the bolt established during the same year on the west side of Lake Creek.



Monument at Boundary Point 33 and reference cairn, Unuk River region.

On August 17 packs were taken over the snow ridge of Mount Middleton to Gracey Creek, and between that date and August 29 camps were established on Gracey Creek and Leduc River. Turning Point 28 was re-established, on the highest part of the snow ridge of Mount Middleton over which the line between Boundary Peaks 40 and 18 passed, as specified by the commissioners in their definition of this point in 1905.[1] From Turning Point 28 the line was re-run across Gracey Creek toward Boundary Peak 24, and the new vista was cleared. Monuments 25, 26, and 27 were set on this line, Nos. 25 and 26 replacing the monuments set on the old line in 1909. The remains of the old monuments were built into cairns referencing the new monuments. Monuments were also placed on Boundary Peaks 23

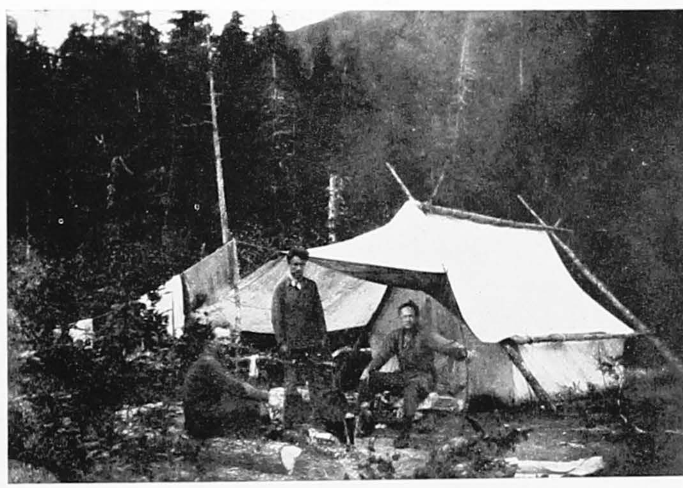


Flag at Boundary Point 28, on the snow-covered ridge of Mount Middleton.

[1] *See* page 53.

and 24, the bolt set in 1909 on the latter peak being left to serve as a reference monument. From the Leduc River camp the vista was re-cut across the river between Boundary Peaks 23 and 18. On this line Monument 19 was set on a spur of the ridge of Boundary Peak 18, the terminus of operations for the Canadian party working from Salmon River; Monument 20 was set near the bolt set in 1909 on the south side of Leduc River; Monument 21 set in 1909 on the north side of the river and Monument 22 also set in 1909 on the slope of Boundary Peak 23 were numbered.

By September 1 the whole party had reassembled at the Unuk River camp. After several days of rain and wind, while the vista cutting, phototopography, and monument numbering were being completed in that region, supplies and equipment were moved down Unuk River to the mouth of Blue River. Light outfits were taken over the lava to fly camps near the boundary in the vicinities of the Lava Fork and the West Fork of Blue River. On Blue River above the Lava Fork the canvas folding boat was used to cross Blue Lake, and it was then lined up the river to the mouth of the West Fork. From the Lava Fork camp Monument 41 was set at the site of the bolt set in 1909 near the glacier on the east, and Monument 42 on the east side of the Lava Fork was numbered. On the west side of the Lava Fork, Monument 43 was numbered and Monument 44 was set on the Albert ridge near the site of the bolt placed there in 1909. From the West Fork camp Monument 45 was set. This was the cone-type monument that had been left west of the Albert ridge in 1909; it was set over a cross on the rock that had been located by triangulation during that year. In addition, $1\frac{1}{2}$ days were spent in cutting vista that had not been cleared in 1909.



Fly camp on the West Fork of Blue River.

On September 28 the party moved down Unuk River to the storehouse at its mouth. On their way down the boat was swept under an overhanging tree and swamped, but by quick work most of the equipment and all of the records and photographic plates were saved. The photographic plates, having become wet from their immersion, were developed in Ketchikan. On October 10 the party was disbanded in Seattle.

The personnel of the party was: engineer in charge, Jesse Hill; assistant, Nelson W. Smith; and 6 hands. The Canadian representative was J. A. Pounder, D.L.S.; assistant, D. F. Chisholm.

MAINTENANCE UNDER THE TREATY OF 1925

Since the adoption of the Treaty of 1925, maintenance on the boundary from the entrance of Tongass Passage to Mount St. Elias has been carried on from time to time by the Commissioners as briefly outlined below. More detailed accounts of these operations are contained in the annual reports that the Commissioners are required to present to their respective Governments under the provisions of Article IV of the Treaty of 1925.

Season of 1925—Stikine River

The vista across the valley of Stikine River was recleared in 1925 by arrangement between the Commissioners and the United States General Land Office.

Season of 1927—Portland Canal

During this year the Commissioners inspected the boundary reference monuments on Portland Canal and the boundary monuments and vista at the head of the canal. No immediate maintenance operations were considered to be necessary on this part of the boundary.

Season of 1929—Stikine and Taku Rivers, Stephens Passage, and Burroughs Bay

During the year 1929 some additional triangulation was required in southeast Alaska to more completely tie the boundary triangulation to the first-order net of triangulation of the United States Coast and Geodetic Survey. This was necessary to enable the Commissioners to determine the geodetic location of the International Boundary line from the entrance of Tongass Passage to Mount St. Elias on the recently adopted 1927 North American datum, common to both countries.

The work was done for the Commission by the United States Coast and Geodetic Survey in conjunction with other triangulation being done in Alaska by field parties of that bureau. This co-operative arrangement between the Commission and the Coast and Geodetic Survey resulted in a considerable saving of public funds as it obviated the duplication of expense that otherwise would have been incurred had separate field parties of the two organizations been sent to this distant locality.

STIKINE RIVER TRIANGULATION (horizontal and vertical angles)

Origin: first-order stations "Dry Pass east base" and "Rynda" on Dry Strait.
Terminus: Boundary Points 62 and 66 (Mount Coté and Elbow Mountain); intersections on Boundary Points 54, 69, 70, and 71.

Length of net	26 miles
Second-order stations occupied	12
Unoccupied check stations	2
Average closure of triangles	3″.4
Maximum closure of triangles	4″.7

TAKU RIVER TRIANGULATION (horizontal and vertical angles)

Origin: first-order stations "Bishop" and "Arden" on Stephens Passage.

Terminus: stations "Twin" and "Azimuth" of the Boundary Commission's 1906 triangulation, 7 miles below the boundary; intersections on Boundary Points 86, 93, and 94.

Length of net	32 miles
Second-order stations occupied	30
Unoccupied check stations	2
Average closure of triangles	2″.5
Maximum closure of triangles	6″.8

In addition, 17 stations of the Taku Inlet triangulation, executed in 1888, 1890, and 1893, were recovered and tied into the new net.

Stephens Passage and Whiting River

In 1906 the Boundary Commission had extended a net of triangulation by way of Port Snettisham and Whiting River to connect the boundary points of this region with the Coast and Geodetic Survey triangulation of 1888 on the west side of Stephens Passage. The plan for 1929 was to tie two or more of the Boundary Commission's stations to the recent first-order net of the Coast and Geodetic Survey along Stephens Passage. While the party was at work in this region, however, early in June, the stations of 1906 could not be occupied on account of the depth of snow. In lieu of the aforementioned plan, an attempt was made to recover the stations of 1888 on the coast from which the Commission's triangulation had been started, but only one of the 1888 stations could be found, station "Zinc". In these circumstances it was decided that the incorporation of station "Zinc" in a quadrilateral with three first-order stations of the Coast and Geodetic Survey in Stephens Passage would be acceptable for the new adjustment of the boundary triangulation. This was accordingly done. The mean and maximum closures of the four triangles involved in this connection were 1″.2 and 2″.5 respectively.

BURROUGHS BAY (horizontal angles)

Origin: first-order stations "Act" and "North Base, 91" at the entrance of Burroughs Bay.

Terminus: stations "Dick" and "Tab" of the Boundary Commission's 1905 triangulation.

Length of net	7½ miles
Second-order stations occupied	12
Unoccupied check stations	1

Season of 1936—Klehini River, White Pass, and Tarr Inlet

Further work in connection with the transferring of geographic positions of the boundary triangulation stations from the southeast Alaska to the 1927 North American datum was undertaken in 1936. During this year the Engineer to the United States Section of the Commission in co-operation with officers of the United States Coast and Geodetic Survey extended a net of second-order triangulation up Chilkat Inlet and Chilkat and Klehini Rivers and a net of first-order

LODE MINING IN THE JUNEAU AND KETCHIKAN DISTRICTS.

By J. B. Mertie, Jr.

INTRODUCTION.

During the last few years gold mining has been increasingly difficult to conduct as a profitable enterprise. The advances in cost of labor and commodities of all kinds have worked a special hardship upon the gold-mining industry, for the standard and unchanging value of gold has rendered it impossible to offset the high prices by increasing the market value of the product, as in other industries. Low-grade gold properties that were formerly worked on a small margin of profit by means of large-scale operations are now either scarcely earning their operating expenses, or are being worked at an actual loss for the sake of enabling the operators to hold their organizations together. Properties of somewhat higher grade are likewise adversely affected, for even for them gold mining has become much less profitable. This condition is reflected in southeastern Alaska by a general policy of retrenchment in mining operations on the part of owners and operators of gold mines. Moreover, present economic conditions have had a very hurtful influence, both economic and psychologic, upon the development of new gold mines.

In the Juneau gold belt the Alaska-Gastineau, Alaska-Juneau, and Treadwell properties were operated in 1919, and prospecting and development work were carried on at the Jualin mine, Berners Bay; at the property of the Admiralty-Alaska Gold Mining Co., at Funter Bay; at the Red Wing group of claims, at the head of Windham Bay; and at the copper property of the Endicott-Alaska Mining & Milling Co., at William Henry Bay. The Peterson mine, at Pearl Harbor, was also worked on a small scale during the summer. Elsewhere in this district mining and prospecting were practically at a standstill.

In the Ketchikan district mining was confined largely to Prince of Wales Island. The Rush & Brown copper mine and the Salt Chuck copper-palladium mine, on Kasaan Peninsula, were operated throughout the year, and the Dunton gold mine, near Hollis, was worked intermittently. Prospecting and development work were continued at the molybdenite property of the Treadwell Co., near Shakan.

JUNEAU DISTRICT.

MAINLAND.

PERSEVERANCE MINE.

The Perseverance mine of the Alaska Gastineau Mining Co., about 4 miles east of Juneau, was operated in 1919 on a basis ranging from 150,000 to 200,000 tons of ore a month, whereas the rated capacity of the mill is 10,000 tons a day. About 460 men were employed. The ore is being taken chiefly from levels 8, 9, 10, and 11. New construction and mine-development work have been greatly restricted, partly because of large increases in operating expenses and scarcity of labor, but also because development work is already considerably ahead of mining operations.

This project is a striking example of the hardship wrought upon the gold-mining industry by the increased cost of labor and supplies. According to data published in a paper by the manager of the Alaska-Gastineau Mining Co.,[1] the cost of supplies of all kinds advanced 35 per cent over the prewar cost in 1917 and 70 per cent in 1918, and it is believed by the writer that the advance reached 100 per cent in 1919. Wages increased 7 per cent in 1917 over the 1916 standard, 25 per cent in 1918, and, it is believed, at least 40 per cent in 1919. The cost of operation has therefore increased steadily during the last three years. The average cost of ore delivered to the mill over a period of four years is shown in the same paper to be about 48 cents a ton, and in view of the increasing costs in the last three years it is fair to judge that the present cost is considerably above this figure. To this must be added milling, shipping, smelting, and administrative charges, which will probably amount to 80 per cent of the cost of ore production. Data on the production of the Perseverance mine, published in monthly statements in the Engineering and Mining Journal, show that the net value per ton during 1919 ranged from 60 to 75 cents and averaged perhaps 70 cents.

ALASKA-JUNEAU MINE.

The Alaska-Juneau mine was operated continuously during 1919, employing about 225 men in the mine and mill. The new 8,000-ton mill, which was completed in 1917 and tried out in 1917 and 1918, was found to be less than 50 per cent efficient, and in 1919 much attention was given to improvements in milling practice. The flow sheet of the mill has been changed materially, and alterations have been made in the milling machinery. The chief improvements have been the introduction of hand picking of the ore as it comes from the

[1] Jackson, G. T., Mining methods of Alaska Gastineau Mining Co.: Am. Inst. Min. and Met. Eng. Trans., 1919, pp. 1547-1570.

12-inch grizzlies, the introduction of the old stamp mill into the flow sheet, and the rebuilding of the tube mills. The first change was necessary to prevent the handling of an excessive amount of waste; the second to avoid overloading the ball mills; and the third to correct poor construction in the tube mills. Milling difficulties are gradually being overcome by these changes.

The lode system at the Alaska-Juneau mine is cut by the Silver Bow fault, which strikes about east and offsets the ore body horizontally 1,000 feet, dividing it into a north and a south ore body. The ore between these two ore bodies lying along the fault is in the nature of fault-plane drag and is irregular in distribution. Present operations are being devoted mainly to cleaning up the old 400 stope, between the two main ore bodies, and to active development of the north ore body. The main haulage tunnel on the north ore body has been extended within 250 feet of the boundaries of the Alaska-Ebner property, and the 420 stope is being actively opened. It is planned to open a 430 stope and successive stopes to the northwest along the north ore body to the limits of the property. In addition, a main haulage way and three level tunnels have been driven in the south ore body, which will ultimately be developed as extensively as the north ore body. The ore mined in 1919 was taken in about equal amounts from the 400 and 410 stopes.

ALASKA-EBNER MINE.

After a period of inactivity of about a year, development work was resumed at the Alaska-Ebner mine of the United States Smelting & Refining Co., near Juneau, in the summer of 1919. A main tunnel running 3,200 feet in a northeasterly direction, thence eastward 1,400 feet, had previously been driven, intersecting the ore body. The present development work consists in the continuation of the main tunnel northeastward from the 3,200-foot point, with the intention of intersecting the ore body farther northwest.

JUALIN MINE.

Development work was continued at the Jualin mine, in the Berners Bay district, owned by the Jualin-Alaska Mines Co., but no ore was produced. Fifty-five men were employed—40 at the lower camp and 15 at the upper camp. At the lower camp work was continued on the 7,000-foot tunnel, which when completed will intersect the ore body at depth and will afford natural drainage for the mine. This tunnel is now being driven by three shifts operating two drills, advancing about 15 feet a day, and in September, 1919, had been driven 2,500 feet. If conditions are favorable, the tunnel should be completed by 1921.

The mine, at the upper camp, was pumped dry in 1919, after being flooded for a year and a half, and development and exploration work was continued. A short drift was driven on the 310-foot level, and several other drifts and crosscuts were expected to be completed before 1920. Exploration was carried on chiefly by means of two long drill holes. The first of these started from the southwest side of the property, on the 310-foot level, and was driven horizontally 1,000 feet to the southwest; the second, beginning at the east side of the mine, likewise from the 310-foot level, had been driven horizontally a little north of east about 1,250 feet in September and was to be continued to 1,500 feet. A third drill hole is planned, which will start from the northwest side of the mine and be driven west with a dip of 18° a minimum distance of 1,000 feet. In the lower tunnel drill holes will be driven every 500 feet at right angles to the tunnel on both sides to the limits of the property.

The mine is now well equipped for development and mining operations. A horse tram connects the wharf at Berners Bay with the lower and upper camps, and all three are connected by telephone. A wireless plant also affords communication with Juneau from the upper camp. Power at the upper camp is developed from Johnson Creek, which with an 80-foot head yields 100 horsepower. The water is turned back into the creek, and at the lower camp, under a head of 576 feet, 500 horsepower is developed. For use in winter, four 150-horsepower Petters semi-Diesel engines have been installed, and these are so adjusted that water may be used in conjunction with the engines when available. A 2,750 cubic foot compressor that uses 350 horsepower and will run 26 drills has also been added to the equipment. The stamp mill, which has a capacity of about 30 tons a day, with two amalgamators and two concentrating tables, at the upper camp, suffices for present mining operations, but plans for future operations include the erection of a new mill of greater capacity and the treatment on a large scale of low-grade disseminated ore, as well as the richer ore from the quartz veins.

The character of the mineralization at the Jualin mine and the number and character of the gold-quartz veins, so far as they were known in 1909, have been fully described by Knopf.[2] In addition to the three quartz veins known at that time, two others lying to the northeast, known as Nos. 4 and 5, have been discovered. The exact significance of these veins is not definitely known, but at present No. 4 is believed to be a different vein from Nos. 1, 2, and 3. Mill practice to date has demonstrated that about 80 per cent of the gold in the quartz veins is free. The remaining 20 per cent is contained with the concentrates, which are chiefly pyrite, with some chalcopyrite and galena.

[2] Knopf, Adolph, Geology of the Berners Bay region, Alaska: U. S. Geol. Survey Bull. 446, pp. 44–47, 1911.

PETERSON MINE.

Gold-lode mining on a small scale was continued on the Prairie claim, at the Peterson property, near Pearl Harbor, in 1919, and resulted in a small production. Recent work has consisted in mining two quartz veins from an open cut, practically at the surface, one about 4 feet and the other about 6 feet thick. The vein material is much weathered, disintegrated, and iron stained. A number of other croppings of vein quartz show on the property, but little exploration or development work has been done. It is certain, however, that a number of quartz veins are present.

The ore is carried by horse tram to a small 3-stamp mill which has a capacity of 1½ tons in 16 hours and is operated by water power. Here the ore is reduced and plated, and the concentrates are collected on a concentrating table. About 80 per cent of the gold is free and is recovered on the plates. The concentrates are shipped to Tacoma for treatment.

MINE OF ENDICOTT-ALASKA MINING & MILLING CO.

A low-grade copper mine is being developed by the Endicott-Alaska Mining & Milling Co. at William Henry Bay, on the southwest side of Lynn Canal, about 8 miles due west of Point St. Mary, at the entrance to Berners Bay. The bay is three-fourths of a mile long and 800 yards wide, is easy to enter, and is considered to be a good anchorage. Beardslee River enters at its head.

The mining property is about a mile west of the head of the bay, 160 feet above sea level. Development work has been in progress for about three years, and it will soon be possible to determine the amount and grade of available ore. Sixteen claims are held, of which 11 have been surveyed for patents.

The geology of the west side of Lynn Canal is complex and has so far been little studied. The strike of the rocks is roughly parallel to Lynn Canal, which is considered to lie along an extended fault zone. Hence correlation between the rocks on the east and west sides of the canal, as no paleontologic data are at hand and the lithologic sequence is imperfect, is hardly warranted. Along the shores of William Henry Bay the bedrock consists of a highly contorted limestone, in part thin bedded and in part more massive, with which some slaty argillite is interbedded, considerable chert, both massive and banded, greenstone flows, and clastic derivatives of the greenstone, classifiable under the general designations greenstone tuffs and graywackes. One of the greenstone derivatives consists of a conglomeratic rock, composed of rounded pebbles of limestone and other rocks embedded in and cemented by the tuffaceous material. Large dikes of diabase cut the stratified series of rocks. North of William

Henry Bay the greenstone tuffs and related rocks are the dominant rocks along Lynn Canal, continuing northwestward to the entrance of Chilkat Inlet, but limestones and other sedimentary rocks are present a short distance inland. South of William Henry Bay the rocks along the coast line are chiefly sedimentary, including argillite, slate, and limestone. It appears, therefore, that the boundary line between the greenstone series and the limestone-argillite rocks may run inland in a general northwesterly direction from William Henry Bay.

The country rock at the mine is in general greenstone tuff with interbedded lava flows, cut here and there by dikes. The tuffs and flows appear to be quite different in petrographic character. The tuffs, which in reality grade into graywacke, are greenish to greenish-gray rocks, of fine-grained texture and very difficult to classify in the hand specimen. Under the microscope they are seen to be clastic rocks composed mainly of angular to subangular grains of acidic plagioclase, chiefly albite and oligoclase-albite, in an indefinite groundmass or cement of sericitic and kaolinic material. They also contain grains of an igneous rock, which on account of the character of the plagioclase feldspar would be classed as sodic trachyte or albite andesite. Commonly these rocks are altered and show more or less calcite, quartz, epidote, and chloritic and sericitic material. In much of the rock the feldspars and other detrital constituents are bent, fractured, and veined by secondary minerals. The interbedded flows, which form a minor part of the sequence at this locality, are difficult to distinguish in the hand specimen from the clastic rocks, for they are likewise greenish and aphanitic. They are somewhat darker in color, however, and under the microscope are found to be basaltic. They are holocrystalline to somewhat glassy; are composed essentially of labradorite, augite (sometimes basaltic hornblende), and iron oxides; and are in places much altered, particularly in the feldspar, which has been changed to sericite. The only dike seen in the mine was a fine-grained holocrystalline rock composed of biotite and augite, with iron oxides and apatite, joined by interstitial albite. This rock is a sodic augite minette.

Along the mountain side southwest and west of the mine rocks of the same general character were seen. At an elevation of 1,200 feet, about S. 40° W. from the head of William Henry Bay, is a steep face of rock known as the Palisades. This rock is a fine-grained greenish-gray graywacke, which under magnification is seen to be composed of subangular to rounded grains of quartz, oligoclase-albite, and felsic rock, in a cement composed of epidotic, kaolinic, and sericitic material. Somewhat higher up, at an elevation of 1,900 feet, is a tuffaceous rock of the same general composition but of coarser grain and approaching more closely a true igneous rock in appearance, which continues upward to a high flat on top of the spur. To the northwest along this ridge the country rock changes to a series of interbedded argillite and limestone.

A short distance northwest of the mine, in a little creek, tuffaceous graywacke of the same general character as that at the mine is exposed. Some of this rock shows considerable dynamic metamorphism, being sheared and rendered more or less schistose. One specimen was found to be essentially a fine-grained quartz-mica schist, although under the microscope the original fragmental character could still be observed.

The copper lode that is being developed is a vein composed chiefly of calcite, with considerable silica in the form of tiny veinlets of quartz and chalcedony. The copper ore is exclusively chalcopyrite and occurs with the quartz. The vein pinches and swells but probably averages 10 feet in thickness. The general strike is about N. 75° E. and the dip 80° S., but there are many local irregularities in attitude, due mainly to faulting. The ore carries only small quantities of gold or silver and is classed as a low-grade copper ore. The mine is being developed on the assumption that a 2 per cent copper ore can be produced.

The tunnel starts on the Bonanza No. 3 claim, cuts diagonally across the Endicott No. 2 claim, and enters the Endicott No. 3 claim. It is driven in a general southwesterly direction and intersects the vein 700 feet from the portal, at a point where the vein shows a displacement of 100 feet to the south, due to a fault. The tunnel follows the vein for 400 feet. Numerous small faults met in the tunnel show displacements of the vein ranging from practically nothing up to 10 feet and suggest step faults to take up the movement caused by larger displacements some distance away. At a distance of 1,100 feet from the portal a crosscut prospect tunnel has been started which will be driven northwestward, in the hope of cutting other veins.

The vein that is being explored in the tunnel crops out on the hillside west of the mine at an elevation of 500 feet. At this point the vein strikes about due east, stands vertical, and has a thickness of about 12 feet, with an 18-inch horse of country rock in the center. The vein material here also is practically all calcite with quartz veinlets and chalcopyrite. A little pyrite was seen, and this has oxidized and caused brown staining of the vein matter, particularly along fractures caused by later movements in the vein. The foot-wall side of the vein is slickensided and grooved, showing that considerable movement has occurred. The country rock is the same as in the mine. It is apparent that faulting is very prevalent and is likely to present some troublesome difficulties in mining.

No other surface outcrops of this or any other veins of mining importance have been found. On the ridge west of the mine, at an elevation of 2,300 feet, is a small calcite vein about 1 foot thick, which carries some quartz, chalcedony, and a little chalcopyrite, with secondary malachite. This vein, which strikes N. 78° E. and stands vertical, is now in part an open fissure, owing to decomposition and solution of the calcite.

Water power is utilized under a head of 300 feet to run a compressor for two drills. No reduction plant has yet been used, and therefore no ore has been milled or shipped. A 30-stamp No. 3 Austin gyratory mill, which was formerly used at the Sea Level mine, on Thorne Arm near Ketchikan, has been purchased and will be installed in 1920. A combination of Wilfley tables and oil flotation will be used. During the summer of 1919 a dock was in process of construction on the southeast side of William Henry Bay, with a depth of 4 fathoms at its outer end at low tide. Substantial buildings have been erected at the head of the bay, on the west side, and a wagon road connecting the bay with the mine has been built.

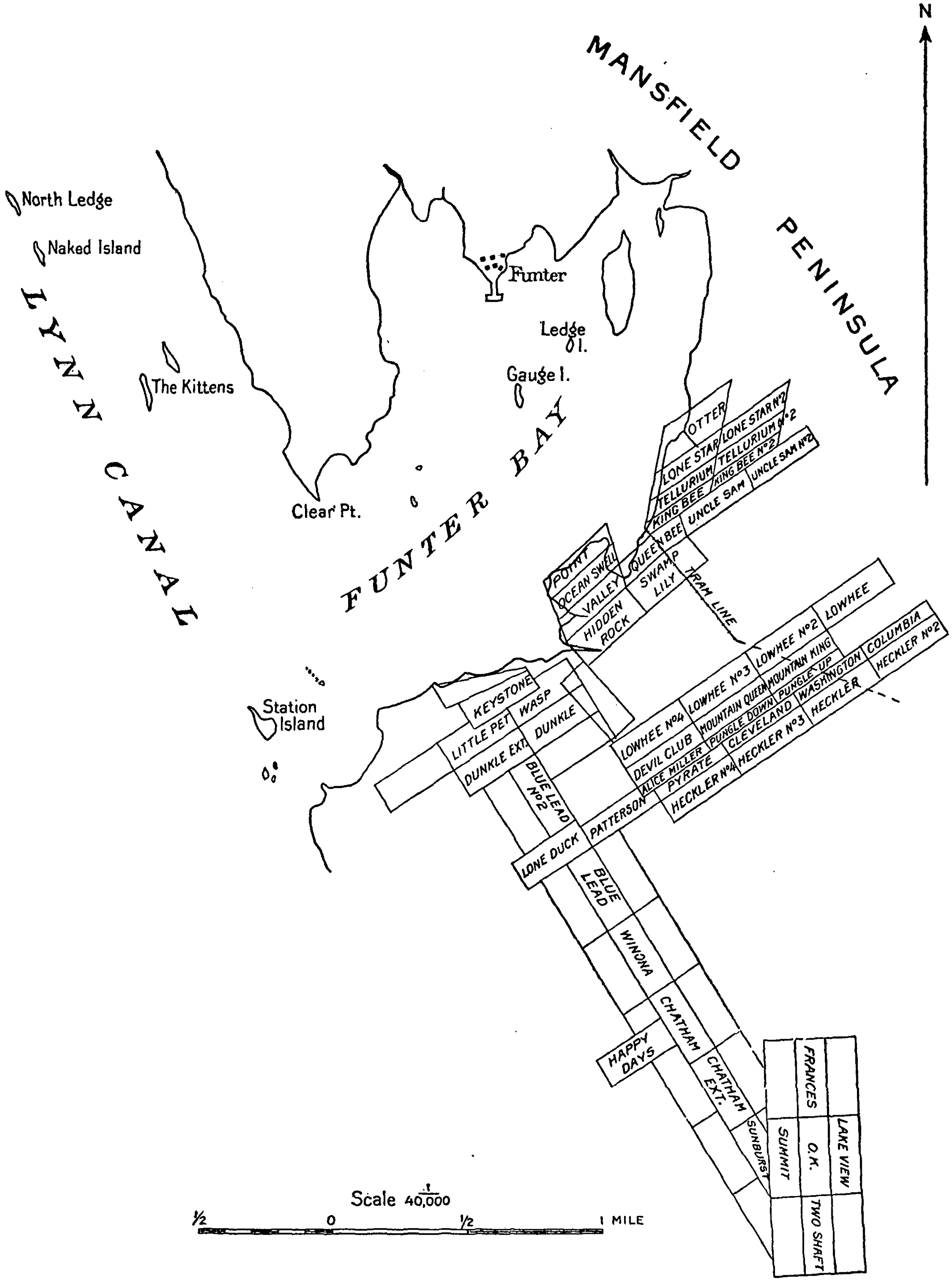
At the lower end of William Henry Bay, along the northwest shore, mineralization has occurred in the rocks at some places. The ore minerals consist for the most part of disseminated pyrites, but at one locality a deposit of sulphides, including arsenopyrite, chalcopyrite, and pyrite was seen in the cherty rocks.

DOUGLAS ISLAND.

The Ready Bullion mine, the one remaining mine of the Treadwell group that was not flooded by the cave-in of 1917, was operated during 1919 at a rate of output of about 24,000 tons a month. About 30 men were employed at the mine, and about 25 at the mill and cyanide plant. The mine now has levels at 2,000, 2,200, 2,400, 2,600, and 2,800 feet, and the main shaft has been extended nearly to 2,900 feet. Most of the ore being mined at present is being taken from the four stopes of the 2,200-foot level, but some is being drawn from the 2,400-foot level. The latest work is the cutting out of three stopes on the 2,600-foot level, preparatory to drawing ore.

The ore is treated at the Ready Bullion 150-stamp mill and cyanide plant. The ore, after being crushed to 40 mesh by the stamps, is conveyed to a small ball mill which reduces the first product to 200 mesh. The oversize is separated by classifiers and returned to the ball mill. The 200-mesh product is conveyed to the cyanide plant, where it is cyanided, washed, filtered, dried, and retorted.

The Treadwell Co. is now operating a 2-ton electric furnace for making steel for its own use in steel castings. Scrap iron collected around the plant has so far been utilized as the raw product, but considerable hematite purchased in Seattle has also been used as a



SKETCH MAP OF MINING CLAIMS, FUNTER BAY, ADMIRALTY ISLAND.

decarbonizer. The carbon content of the steel is reduced to 0.3 to 0.5 per cent. The other necessary ingredients, including ferrosilicon, chrome, manganese, and aluminum (used as deoxidizer), are also purchased. Local magnetites from Haines and Port Snettisham have been tried in place of hematite, but they require too high temperature and too much coke. Both these magnetites have been found to contain considerable TiO_2, and that from Port Snettisham carries some P_2O_3. A few iron and brass castings have also been made.

ADMIRALTY ISLAND (FUNTER BAY).

GENERAL FEATURES.

Funter Bay, on Admiralty Island, is a well-known harbor on the east side of Lynn Canal, practically at the junction of Lynn Canal, Chatham Strait, and Icy Strait. It is a safe and convenient anchorage, and on account of the frequency of stormy weather on Lynn Canal and Chatham Strait it is much visited by small boats. The bay has a general northeasterly trend and is about 2 miles long and three-fourths of a mile wide at the entrance. A cannery and a post office (Funter) have been established on a point on the north side of the bay. Funter Bay is but 18 miles from Juneau in an air line, but 50 miles or more by water.

The shore line of Funter Bay is in general a cliff that rises 20 feet or more above sea level and is bordered by a low-terraced platform which rises gradually to the hills behind. On the northeast side of the bay this platform connects with low hills, but on the southeast side the lowland area gives way to high mountains that rise abruptly to an elevation of nearly 4,000 feet. Both lowlands and mountains are timbered, the mountains up to an elevation of about 2,500 feet.

The lode properties lie chiefly along the southeast side of the bay, beginning at the shore line and extending up into the high hills. Gold-quartz veins were discovered at this locality in 1887, and a number of properties have been held since that time. Many quartz veins have been discovered and a good deal of prospecting has been done, but as yet there has been little mining. At the present time development work is being done on the claims of the Admiralty-Alaska Gold Mining Co. and prospecting is being continued on the Nowell-Otterson group of claims. The former embrace two groups of claims, a lower and an upper group, about midway of the bay on the southeast side; the latter adjoin these claims on the southwest. A good-sized stream, Mountain Creek, lies between the two properties. The general position of these two groups of claims is shown on the accompanying map (Pl. IV).

The claims, particularly those of the Admiralty-Alaska Gold Mining Co., have been examined a number of times by different members of the Geological Survey, and two reports [3] have been prepared and published. No extensive study of the regional geology has so far been attempted, but the different quartz veins have been fairly well described. The present notes are only supplementary to the earlier reports.

The general geology has been briefly described by Eakin [4] as follows:

The rocks of the Funter Bay district include a highly altered bedded series, dominantly greenstone schist and subordinately limestone or marble, and a few small dikes of diabase, andesite, and diorite, which cut the bedded rocks at wide intervals. The schistose cleavage of the metamorphic rocks is generally parallel with the bedding planes. Locally intense crumpling and close folding on a small scale are apparent, but in general the bedded rocks lie in broad and gentle folds. Over considerable areas both schistosity and bedding are near the horizontal. Joint systems on both large and small scales cut the bedded rocks at high angles with the schistosity and bedding or near the vertical. The major joint planes in places persist for hundreds and even for a thousand feet or more with great regularity in strike and dip. Such large fractures were probably accompanied by some differential movement between the blocks which they separate, but there is no definite indication of the maximum displacement. These planes are generally marked by quartz veins, which range in thickness, in the different individuals observed, from mere films to nearly 60 feet. At one locality four approximately parallel veins were measured in a section 330 feet across, whose thickness aggregated 90 feet. Obviously the introduction of this amount of quartz in a narrow section involved displacement of masses of the rock. T-shaped and L-shaped bends in some of the veins indicate differential movements amounting at least to the thickness of the veins. Other veins, which gradually thin out to their ends, do not have this significance. Faults later than the veins and offsetting them occur only here and there, according to present evidence.

The metamorphism of the bedded rocks is for the most part of regional character and of earlier age than the igneous dikes or the quartz veins, which are unsheared. Later metamorphic agencies have affected the bedded rocks locally, adjacent to the quartz veins, resulting in silicification and bleaching of the greenstone schists, accompanied by the introduction of sulphide minerals and in places of gold. Such minerals also occur in bands of greenstone schist without associated quartz veins at two localities, but they are not believed to represent a distinct period of mineralization.

The schists of the Funter Bay area, grouped by Eakin under the general designation of greenstone schist, consist of a variety of rock types, including chlorite schist, mica schist, quartz-chlorite schist, quartz-chlorite-mica schist, zoisite-chlorite schist, albite-zoisite schist, albite-chlorite schist, and albite-mica schist, as well as nonschistose blocky rocks of the same general character, usually carrying little mica. Among the metamorphic rocks are also to be found gneissoid rocks, including albite granite gneiss and albite syenite gneiss. Normal dioritic or andesitic rocks were not observed by the writer, but a variety of other dike rocks containing plagioclase high in soda were recognized. These are chiefly albite granite, albite syenite (or albite diorite), and albite trachyte. One dike of olivine diabase was noted.

[3] Wright, C. W., A reconnaissance of Admiralty Island: U. S. Geol. Survey Bull. 287, pp. 147–150, 1906. Eakin, H. M., Lode mining in the Juneau gold belt: U. S. Geol. Survey Bull. 662, pp. 84–92, 1918.

[4] Eakin, H. M., op. cit., pp. 84–85.

The above is by no means an exhaustive list of the different varieties of rocks found at Funter Bay but is given chiefly to illustrate a feature of these rocks that has been generally overlooked, namely, their sodic character. All the acidic and intermediate types of intrusive rocks examined by the writer contain albite or oligoclase-albite plagioclase feldspar, and albite is also of common occurrence among the schists and gneisses. This feature is of more than passing interest when considered in relation to the sodic character of the intrusive rock at the Treadwell mines, on Douglas Island, about 15 miles to the east. It is not unlikely that mineralization at these two localities took place at the same general period and had a similar origin.

CLAIMS OF ADMIRALTY-ALASKA GOLD MINING CO.

The Admiralty-Alaska Gold Mining Co. holds 52 claims, of which the principal ones are shown on the accompanying sketch map (Pl. IV). These claims lie in two groups, a lower group on the low terrace leading back from the beach, and an upper group on the mountain slope to the southeast. In the lower group the principal lodes are the Tellurium, King Bee, Uncle Sam, and Lone Star; a number of smaller veins also occur. The upper group includes a large number of veins, among the most valuable of which are the Blanket lode, the veins on the several Heckler claims, including the Big lode and the Washington lode, the Devil Club lode, and the Patterson lode. Both the lower and the upper veins have been described adequately by Eakin, and no new work has been done on their surface outcrops in the meanwhile.

A tunnel is now being driven from the end of the tram line to prospect the quartz veins of the upper group. This tunnel starts about a mile from the beach, at an elevation of about 250 feet, and is being driven S. 65° E. with the intention of crosscutting at depth the veins on the Lowhee No. 2, Mountain Kink, Pungle Up, Washington, and Heckler claims. Work was begun on this tunnel in the fall of 1918, and by midsummer of 1919 it had been driven about 800 feet. One drill is being used.

A compressor plant, with a capacity of 12 drills, has recently been installed. Water power under a head of 500 feet, delivered to the compressor in a 6-inch stream, is utilized. A sawmill has also been built. From 5 to 15 men were employed during the summer of 1919.

The tunnel is driven in a greenstone schist, which differs in character in different parts of the tunnel. At the face in 1919, about 800 feet from the portal, it consists of a recrystallized rock, somewhat schistose in appearance, composed essentially of a mixture of zoisite and chloritic material, chiefly pennine, together with considerable quartz and some pistacite and titanite, and would be designated a zoisite-chlorite schist. The dip of the schist in the tunnel is in general away from the beach. About 400 feet from the portal a small ore body consisting of a sheared mixture of quartz and schist, with about 8 inches of milky quartz on the hanging wall, was intersected. This vein and its accompanying zone of shearing is parallel with the cleavage of the schist. The sulphide minerals include pyrite, pyrrhotite, and a little chalcopyrite. The hanging wall was found to be a fine-grained igneous rock, with a pronounced flow structure, composed essentially of unaltered oligoclase-albite in tiny laths, forming a felty trachytic groundmass, and an interstitial filling of chloritic material, derived probably in part from rock glass. Some larger laths or phenocrysts of oligoclase-albite are partly altered to epidote and calcite. Secondary quartz, epidote, and calcite are present. This hanging-wall rock is a sodic trachyte.

No other quartz veins of any importance have so far been crosscut, but it is planned to continue the tunnel until the Heckler Blanket lode, the Big lode, and other veins that crop out on the Heckler group of claims are intersected. No accurate base map of the property has been made, but it is estimated roughly by the writer that a 2,000-foot tunnel will be required to reach the Heckler Blanket vein, if the strike and dip shown at the outcrop continue below the surface to the level of the tunnel. The strike and dip of the Big lode are not sufficiently well known, owing to the lack of stripping at the outcrop, to justify a guess as to how far the tunnel will have to go to cut this large body of quartz. The vein crops out farther southeast than the Heckler Blanket vein, but the dip may be lower, thus partly or wholly compensating for the greater surface distance.

NOWELL-OTTERSON CLAIMS.

The Nowell-Otterson group of claims lies southeast of the property of the Admiralty-Alaska Gold Mining Co. and includes 19 claims stretching from Funter Bay to the top of the mountain to the southeast. The general position of these claims is indicated on the accompanying sketch map (Pl. IV). A good trail has been built from the bay to the top of the mountain, making these claims easy of access.

On the Winona claim, at an elevation of 675 feet, a tunnel 64 feet long has been driven on two quartz seams, which strike about N. 55° E., conformably with the country rock, and dip southeast. The upper of these seams is fairly persistent and ranges from 6 to 24 inches in thickness; the lower seam is lenticular and discontinuous. The footwall is graphitic chlorite schist, and the hanging wall a quartz-mica schist. The quartz is iron stained and carries stringers of country rock. Some pyrite and pyrrhotite were seen in the quartz.

On the Chatham claim, at an elevation of 1,050 feet, a tunnel has been driven 200 feet and crosscuts four thin quartz seams, from 2 to 4 inches wide, which strike N. 45° E. and dip 45° NW., thus cutting almost directly across the structure of the country rock, a quartz-mica schist. The quartz carries pyrite, pyrrhotite, and gold.

To the east of the tunnel, on a small creek, several small quartz veins of similar character are exposed. A small shipment of ore (about 5 tons) from one of these veins, which ranges in thickness from 8 inches to 2 feet, was valued at $120 a ton, and a second sample at a later date ran $80 to the ton. At least 10 such small veins, most of them measurable in inches, are exposed in the creek. The quartz carries pyrite, pyrrhotite, and in places a little galena, in addition to the gold.

The vein of most interest on the Nowell-Otterson group is the Big Thing lode, which crops out on the line between the Francis and O. K. claims at an elevation of 3,100 feet and has been traced 800 feet to the north and over 1,500 feet to the south. The vein, which strikes about N. 20° W. and dips steeply to the east, lies parallel with the schistosity of the country rock. The hanging wall is a chlorite schist composed of chloritic material, quartz, calcite, and epidote. The footwall is a graphitic schist. On the line between the O. K. and Francis claims about 20 feet of quartz is exposed, with a horse of schist in the center of the vein. The quartz is heavily iron stained and is mineralized by iron sulphides (pyrite and pyrrhotite), galena, and hematite. It is characteristic of these sulphides to be concentrated in pockety masses in the quartz. The owners aver that the average of assays so far made is about $5 to the ton in gold.

On the Two Shaft claim, about 1,800 feet north of the outcrop just described, at an elevation of about 3,050 feet, a vein of quartz from 15 to 25 feet thick crops out and is believed to be the continuation of the Big Thing lode. The country rock here is a quartz-mica schist, and the vein strikes about N. 15° W. and dips steeply to the east, as at the other locality. The quartz is of the same general character as the quartz above described, but more galena is present, and some chalcopyrite was also seen. A good deal of free gold may be seen with the naked eye, and it is apparent that some of this material is high-grade ore.

Another vein, distinct from the Big Thing lode, also crops out on the Two Shaft claim, some distance west of the one just described, at an elevation of about 2,750 feet. This is a smaller vein of quartz, about 30 inches thick, striking N. 20° W. and dipping steeply to the east, which lies comfortably with the schist and is heavily impregnated with sulphides. The quartz where unaffected by the mineralizing solutions is white and milky, but elsewhere it is heavily iron stained. Pyrite, galena, chalcopyrite, and specular hematite are found with the quartz. Green malachite staining and to a lesser extent blue azurite discoloration are apparent. An irregular body of calcite cuts transversely through the vein and appears to represent a later phase in the sequence of mineral deposition. This vein carries very little gold but is reported by the owners to give high assay results in silver and lead.

A number of other quartz veins crop out on this mountain in the vicinity of the O. K., Two Shaft, and Summit claims, but little prospecting has been done on them, and therefore little is known of their character and extent.

KETCHIKAN DISTRICT.

PRINCE OF WALES ISLAND.

SHAKAN MOLYBDENITE LODE.

A molybdenite lode was opened in 1917 by the Alaska Treadwell Mining Co., and development work has continued to the present time, although no ore has yet been shipped. This lode is about three-fourths of a mile south of Shakan, at an elevation of 600 feet, at the north end of Prince of Wales Island, on the east side of a small stream that enters Shakan Bay.

The country rock consists of tuffaceous sediments intruded by diorite. The lode is in diorite, which varies somewhat in character and composition but in general is composed of zonally grown plagioclase feldspar, ranging from albite on the rims to bytownite in the centers of the crystals, and with an average composition perhaps of andesine; a small amount of orthoclase; considerable hornblende; and biotite, augite, iron oxides, and apatite. Being composed essentially of plagioclase feldspar and hornblende, this rock is classed as a hornblende diorite. Pegmatite is present in dikes and veins cutting the diorite and is in fact related genetically to the molybdenite in the lode. The pegmatite is composed essentially of orthoclase feldspar and quartz, with accessory sphene and small amounts of secondary sericite, chlorite, and epidote.

The vein at its maximum is 6 feet thick, with a strong, clean-breaking hanging wall and an indistinct footwall. It varies considerably in strike and dip, as is shown by the crookedness of the main tunnel which follows the vein. The average strike is about N. 70° W. and the dip ranges from 10° to 25° S. Considerable faulting is apparent, particularly along the hanging wall, where in places the vein matter for 6 inches or more has been reduced to a fault gouge. Some of the best of the ore has been taken from this zone along the hanging wall. The gangue of the vein is partly quartz and partly pegmatitic material, and these two appear to grade into one another, indicating that at least a part of the quartz is of primary origin. The sulphide minerals in the gangue include molybdenite, pyrite, pyrrhotite, and chalcopyrite. The molybdenite is in some places scattered through the quartz and pegmatite and in others more or less concentrated, particularly in the gouge zone. Pyrite and chalcopyrite are distributed throughout the gangue, but pyrrhotite is most often found in pockets or kidneys. The paragenesis of the sulphide minerals has not been deciphered.

A tunnel, now driven 360 feet, is the main underground development work. At 250 and 300 feet from the portal cross faults were met, the first striking N. 10° E. and the second N. 10° W., with offsets at both places. The molybdenite content of the vein becomes very low beyond the 300-foot point in the tunnel, and at this point the direction of the tunnel was changed to one somewhat south of the strike on the working hypothesis that the true vein at the 300-foot point has been replaced through faulting by a barren quartz vein. It is equally possible, however, that a molybdenite ore shoot in the vein has been terminated by the fault, and that the vein exposed beyond the fault is a barren zone of the same vein. In this event, further drifting on the vein or sinking an inclined shaft down the dip will afford the greater chance of discovering ore.

A tramway has been constructed from the portal of the tunnel across the small stream above mentioned and down the opposite side of the valley to tidewater. A small dock has also been built. All the mining has so far been done by hand, but in September, 1919, a compressor plant was at the dock awaiting installation. Six men, working in two shifts, were at work at the time of the writer's visit.

RUSH & BROWN MINE.

The Rush & Brown mine, about half a mile west of Lake Ellen, at the head of Kasaan Bay, was the only copper mine in southeastern Alaska that was operated in 1919. The property includes two ore bodies that have been developed to a productive basis and a number of others that have not been explored. The larger of the two productive ore bodies is a contact-metamorphic deposit of copper-bearing magnetite, and the smaller a fault-zone deposit, with chalcopyrite as the chief sulphide. The former is of too low a grade to be worked at the present price of copper; but the latter carries a higher grade of copper ore and also considerable gold and silver, and in recent years mining has been confined to this deposit. Eight men were employed in the mine in 1919, and several others at the surface.

The contact-metamorphic deposit lies in contact rock between diorite and graywacke, trends about due east, and stands practically vertical, plunging perhaps at a high angle to the north. The ore has been exposed in a glory hole and numerous drifts from it to a depth of 140 feet, for a distance of about 200 feet, and shows a width ranging from 50 feet at the west end to 125 feet at the east end. The deposit, however, is irregular in outline and variable in ore content, owing to the inclusions of numerous horses of country rock. Both the ore and the country rock are much faulted, but in general the throw of the faults seems to be small. A series of lamprophyric dikes, chiefly sodic vogesites, cut directly across the magnetite and country rock, striking in general about north. These dikes appear to represent the latest phase of the igneous activity. The chief sulphides contained in the magnetite are chalcopyrite and pyrite, but they are so scattered that it is difficult to find copper ore of a commercial grade. The whole deposit of cupriferous magnetite, if mined completely, should yield not less than 0.5 per cent and possibly 1 per cent of copper. Such ore should sometime become of value, if worked for both its copper and its iron content.

About 160 feet north of the contact ore at the surface lies the shear-zone deposit, observations upon which show that the vein is irregular in attitude, ranging in strike from N. 65° E. to east and in dip from 45° to 60° S. If the strike is taken at N. 80° E. and the dip at 60° S., it appears that the shear zone should intersect the contact deposit at a vertical depth of about 280 feet from the surface, or about 325 feet measured down the slope. The inclined shaft down the vein on the shear zone has now been sunk 430 feet but without yet encountering the contact deposit. This may be due to faulting.

The deposit now being worked is a body of sheared graywacke and tuff, ranging in thickness from a few inches to 8 feet, lying between well-defined foot and hanging walls. The sulphide ore, chiefly chalcopyrite with some pyrite and pyrrhotite, occurs in lenses and reticulating veins and veinlets within the sheared material, more commonly nearer to the hanging wall than to the footwall. Some solid veins of chalcopyrite have been found, of which the largest so far mined has not exceeded 4 feet in thickness. The gangue material consists of crushed country rock, rather than gangue minerals such as quartz or calcite. The two walls evidently represent the outer limits of movement, for they are slickensided, and the sheared and crushed vein material ends abruptly against them. Moreover, the ground outside the vein is firm, as indicated by the fact that no timbering is required in the drifts. As would be expected, ore is found in soft ground, where shearing and granulation have reached a maximum. There appears to have been little if any movement along the vein subsequent to ore deposition, but cross faulting is not uncommon. On the 200-foot level a well-marked fault, known as Murphy's slip, intersects the vein, offsetting it 25 feet on this level. This fault strikes approximately north and dips 50°–80° E., and has been traced 400 feet by tunnel. Faults similar in strike and dip may be seen on other levels, particularly west of the shaft, and appear to constitute a system of parallel faults formed subsequent to ore deposition. It seems likely that the dikes of vogesite previously mentioned were intruded along such fracture planes.

At several localities in the mine small deposits of cupriferous magnetite lead off from the vein, existing apparently as isolated outliers of the contact deposit near by and relating the two types of deposits genetically to the same agency—the intrusive diorite. Small ore shoots of commercial copper ore were found in some of these deposits and mined.

The mine is developed by levels at depths of 100, 200, 250, 300, 350, and 400 feet. A vertical shaft connects the 200-foot level with the surface, and a hoist operates a lift which handles either men or an ore car. The lower levels are reached by ladder down an inclined shaft that follows the vein; and ore from the lower levels is raised up this shaft on a skip. A moderate flow of water, about 50 gallons a minute, is raised by a pump from the lower levels to the 200-foot level, whence it goes into a sump and is picked up by another pump and hoisted to the surface.

All mining and development work so far has been done by hand mining, but a new Ingersoll-Rand compressor, with a capacity of four drills, has been partly installed and should soon be ready for use. A small boiler of about 50 horsepower, operated on wood, now supplies all the power that is needed; but a larger boiler is being installed to run the compressor. The output of the mine should be materially increased by the use of power drills. The ore is transported by a small locomotive and cars over a narrow-gage railroad to tidewater, a distance of about 2 miles.

SALT CHUCK MINE.

The Salt Chuck mine, formerly known as the Goodro mine, is about half a mile northeast of Lake Ellen and at an equal distance from the head of the Salt Chuck, at the head of Kasaan Bay. Mining was begun originally on what was considered to be a low-grade copper deposit, but subsequently it was discovered that the ore was of more value for its content of platinum metals than for its copper, so that now this mine is more properly described as a palladium-copper mine. It has been operated continuously since 1917, and in 1919 it employed about 16 men.

The lode crops out at an elevation of 400 feet, upon a little knoll rising from one of the rounded ridges characteristic of this glaciated area. A few other surface outcrops have been found near by, but the general surficial configuration of the mineralized zone has not been determined, owing in part to the timber and dense vegetation of the surrounding area, but particularly to the irregular distribution of the mineralization, which gives no clue as a guide in prospecting. The ore zone, however, or the zone within which the discovery of ore shoots may be expected, is believed to be at least 250 feet wide and is thought to extend in a direction about N. 75° W.

This deposit, unlike most of the other commercial ore deposits of Kasaan Peninsula, occurs in an area of coarse-grained intrusive rock, which has been mapped by Wright[5] under the general designation granitic intrusives. Such intrusive rocks invade the Paleozoic sedimentary rocks of Kasaan Peninsula at many localities, occurring as small and large bodies of varying petrographic character. The normal type of these rocks is a diorite, low in quartz and orthoclase, but numerous other facies have been evolved by magnetic differentiation. In the acidic differentiates low potassium and high soda content expresses itself through the formation of sodic granite and syenite, the chief feldspar of which is albite, in place of orthoclase, the normal type in such rocks. Much diversification is apparent among the basic types of differentiated rocks, although few of these have been described in any detail. This differentiation is well illustrated at the Salt Chuck mine, where the country rock is in general a pyroxenite, with gabbroic and gabbro-pegmatitic phases. Wright referred to the country rock at the Salt Chuck mine as a gabbro, but in his petrographic description he showed clearly that the plagioclase feldspar constitutes only from 5 to 10 per cent of the rock. It seems better, therefore, to designate the intrusive rock at the mine pyroxenite, remembering, however, the gradual transition to the true gabbroic intrusives in this vicinity. The chief rock-forming mineral is augite, and the subordinate constituents are biotite, iron oxides, plagioclase, apatite, and titanite, though not all of these are invariably present in any one specimen. Biotite in particular is variable in distribution, and much of it occurs as large splendent crystals. The pyroxene and plagioclase are in places much altered, the alternation resulting in the development of rocks rich in epidote and in chloritic and sericitic material.

The ore minerals consist of copper sulphides, distributed in grains and small patches as ore shoots in the pyroxenite. Bornite is the chief copper mineral, but a small proportion of chalcopyrite also occurs locally. Chalcocite and covellite are both present, as alteration products of the bornite and also of the chalcopyrite. Finely disseminated chalcocite and native copper have been reported by Knopf[6] as occurring in some drifts about halfway between the upper and lower tunnels, leading from a connecting winze. Practically no gangue minerals are found with the ore. In addition to copper, gold, silver, palladium, and platinum are recovered.

[5] Wright, C. W., Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska: U. S. Geol. Survey Prof. Paper 87, p. 73, 1915.

[6] Knopf, Adolph, Mining in southeastern Alaska, 1910: U. S. Geol. Survey Bull. 480, p. 101, 1911.

The metallic content of the Salt Chuck ores was shown in a table of analyses by Campbell,[7] and this table, with the addition of three determinations of concentrates, is given below.

Metallic content of Salt Chuck ores.

[Copper in per cent; other metals in ounces to the ton.]

	Copper.	Gold.	Silver.	Platinum.	Palladium.
Gloryhole	1.92	0.07	0.17	0.41	
150-foot level	1.08	.07	.24	.18	
Bottom of winze	1.28	.05	.24	.17	
Average of ore analyses	1.427	.063	.217	.253	
Gabbro	.06	.01	.10	.01	
Chalcopyrite	27.66	.11	2.08	1.01	
Concentrates	43.81	1.17	4.60	3.54	
Concentrates (Eng. and Min. Jour., Sept. 27, 1919)	36.96	1.27	6.10	0.10	2.93
Concentrates	....	....	....	.04	2.56
Concentrates	39.41	1.20	5.18	.04	3.38
Average of concentrates	40.06	1.213	5.293	3.147	

From these data it is possible to estimate the percentage recovery of the precious metals in the concentrates. If the concentrates average 40.06 per cent of copper each ton of concentrate will contain 801.2 pounds of copper. Then, as the average copper content of the ore is 1.427 per cent, each ton of ore contains 28.54 pounds of copper; and the number of tons of ore used to produce 1 ton of concentrates, on the assumption of a copper recovery of 100 per cent, would be $801.2 \div 28.54 = 28.07$ tons. The recovery of gold, silver, and platinum metals in ounces per ton is obtained by dividing their respective figures in the "average of concentrates" by 28.07; and the ratio of the resulting quantities to the corresponding quantities given in the "average of ore analyses" yields the percentage of recovery for the precious metals in terms of the assumed 100 per cent recovery of copper—that is, gold 68 per cent, silver 87 per cent, and platinum metals 44 per cent. The exact percentages of precious metals recovered are obtained by multiplying these computed percentages by the true recovery of copper.

On reducing the copper percentage to troy ounces per ton and comparing the result with the figures for the precious metals, it appears that the ratio of the copper to the gold, silver, and platinum metals is 6,607, 1,918, and 1,645 to 1 respectively, and that the ratio of the gold to the silver and platinum metals is roughly 1 to 3 and 4 respectively. Of course, an average of three assays affords no basis for any exact deductions, but nevertheless these figures are useful in giving a general idea of the occurrence of these metals.

[7] Campbell, D. G., Palladium in Alaska lode deposits: Min. and Sci. Press, vol. 119, pp. 520–522, 1919.

A little free gold may be seen in some of the ore, but the disparity between the recovery of gold and the recovery of platinum metals leads to the belief that a considerable part of the gold is chemically combined or mechanically held with sulphides. The high content of silver relative to gold indicates an additional source of silver besides that alloyed with gold, and the high silver recovery indicates that the silver is present as some silver or copper-silver mineral, probably a sulphide or sulpho-salt, which is highly adapted to the flotation process. Possibly it occurs in both these forms. The high content but low recovery of platinum metals, when considered in the light of the known relationship between copper and platinum metals in these ores, indicates that the larger part of the platinum metals are held mechanically by the copper minerals and are liberated in the ball mill. The ratio of palladium to platinum appears to vary considerably but is believed to average about 50 to 1.

The analysis of the chalcopyrite is also of some interest. Gold, silver, and platinum metals are found in the chalcopyrite, and although this fact does not permit any inferences as to the state of existence of the precious metals, it serves partly to corroborate the nfluences above drawn. The ratio of gold to silver to platinum metals in the chalcopyrite is about 1 to 19 to 9, whereas in the average of ore analyses it is 1 to 3 to 4. The higher ratio of silver to gold in the chalcopyrite analysis is probably due in part to the lower content of gold in the chalcopyrite than in average ores, owing to the presence of a certain percentage of free gold in the country rock; but probably it is due more largely to the higher content of silver in the chalcopyrite, as a result of the presence of intergrown silver or copper-silver sulphides. The higher ratio of platinum metals to gold in the chalcopyrite analysis is interpreted as evidence that more of the platinum metals are associated with the copper minerals than occur free in the country rock, thus corroborating the relationship that appears to exist between the copper and platinum metals in the mine. The analyses above given show from 0.13 to 0.21 ounce of platinum metals to the ton for each 1 per cent of copper; the lower figure is more probably representative of the average.

The mode of formation of this deposit and the distribution of the ore present some puzzling features. The country rock, though mainly pyroxenite, shows gabbroic and gabbro-pegmatitic phases, and at the west end of the glory hole a basic dike 4 feet thick cuts the pyroxenite. Considerable epidote also occurs, in part replacing the minerals of the country rock and in part as traversing veinlets. The ore is evidently later than the dike, for a bornite-chalcopyrite ore shoot cuts directly across the dike. The country rock is much fractured, but there is no particular system to the fractures, and no large displacements. The general trend of the zone of the fractured and faulted rock, however, is believed to be about N. 75° W.

At first sight the bornite and chalcopyrite may be regarded as ores segregated from the gabbro mass. The copper minerals do not appear to follow the larger fracture planes to the extent that might be expected in an ore deposited from circulating waters. The ore occurs in shoots, which appear more or less independent of the rock fractures, and the bornite is found as disseminated particles within these shoots, some of it in massive country rock at some distance from any apparent openings. Also, free gold was observed which had been drawn out and elongated by faulting subsequent to its deposition, showing that at least some of the fracturing movements occurred after the deposition of the ore. On the other hand, some of the copper ore, particularly the chalcopyrite, lies along the fractures in such a manner as to show clearly that it entered the rocks and was deposited subsequent to the fracturing. Moreover, where the bornite occurs in massive, unfractured pyroxenite, the rock-forming minerals of the pyroxenite are noticeably altered, chiefly to epidote, with less chloritic material; and the degree of this alteration appears to be a function of the amount of ore present. Finally, the texture of the ore as seen under the microscope belies the appearance of primary character which is seen in hand specimens. The country rock contains many minute cracks, adequate for circulating ore solutions, and the ore itself shows that it has entered the rock in this manner and replaced the rock minerals. Hence, though all the details of the ore deposition can not be explained, it seems certain that this is at least an epigenetic deposit—that is, it was formed later than the containing country rock.

The presence of chalcocite, covellite, and native copper point unmistakably to enrichment, due to the action of meteoric waters working downward from the surface. The chalcocite and native copper observed by Knopf [8] were at a depth of about 200 feet below the surface and shows that enrichment has occurred at least to this depth. This is rather remarkable for southeastern Alaska, for it has generally been believed that in that region the recent glaciation had removed the zone of oxidation and practically all of the secondary sulphide zone. It would be of interest to know whether this supergene enrichment is a remnant representing a preglacial secondary sulphide zone, or whether it has occurred in postglacial time. In either case the theoretical conclusion is that the ore will be found to become leaner with depth, but it is doubtful if this feature will prove of much economic importance, as the percentage of secondary sulphides appears to be relatively small.

[8] Knopf, Adolph, Mining in southeastern Alaska, 1910: U. S. Geol. Survey Bull. 480, p. 101, 1911.

The Salt Chuck ore deposit has been developed at the surface by a small glory hole and an open cut almost adjoining it on the east, and underground by a tunnel 300 feet long which at its face opens upward through a stope into the glory hole. Near the face of this tunnel a winze has been sunk 200 feet, connecting with a new lower tunnel, and the winze has been continued upward as a raise for 90 feet. A tram 2,200 feet long has heretofore been used to transport ore from the mine to the mill. The new lower tunnel, 1,225 feet long, has now been completed and will be used as the main oreway.

Ore is now being taken from the stope that connects the upper tunnel with the glory hole. One of the difficulties of mining operations at this property is the irregular distribution of ore stopes. There are practically no data on which to base prospecting, for there is no vein or well-defined shear zone, and the stopes occur seemingly at random. There is a limit to the mineralized zone, which probably coincides with the limit of the faulted and fractured area of peridotite, but this is neither sufficiently definite nor sufficiently circumscribed to be of value in laying out the mine. That such a limit exists is shown in the new lower tunnel, which is 1,225 feet long and in which no ore was seen until the tunnel had been driven 990 feet. The horizontal sequence in this tunnel from the portal inward is as follows:

Sequence in lower tunnel of Salt Chuck mine.

	Feet.
Barren country rock	990
Zone of disseminated bornite	15
Barren country rock	15
Zone of disseminated bornite	30
Barren country rock	170
Zone of disseminated ore, chiefly chalcopyrite, subordinately bornite	5

It is not known in what manner the ore zones shown are cut by the tunnel, and the thicknesses given, therefore, may or may not represent true cross sections of the shoots.

The ore is reduced in a concentration and flotation plant on the property. Power for the mill and mine is generated partly by water and partly by means of a 75-horsepower Fairbanks-Morse semi-Diesel engine. Water is taken from a 31-acre lake and delivered to the wheels in a 10-inch stream, under a head of 179 feet; and when the supply is adequate, 220 horsepower is generated by this means. The supply of water, however, is usually inadequate, and the engine has to be run much of the time. This constitutes one serious handicap to economical mining.

Ore is delivered at the mill into a 175-ton storage bin, from which it goes through two sets of jaw crushers and is reduced to about 2-inch size. This material is then dumped into a 75-ton bin, whence it is fed automatically to a Worthington ball mill, with a rated capacity of 60 tons in 24 hours. Final grinding is at present accomplished by this operation, but the ball mill is overtaxed, and it is planned to introduce rolls between the crushers and the ball mill, reducing the product to 1¼-inch size before delivery to the mill. This will be a great improvement. The pulp from the ball mill goes to a classifier, from which the oversize is conveyed back by a scraper belt to a trommel, while the fines flow off and are raised by a bucket elevator belt to the flotation cells. The oversize from the trommel goes back to the ball mill, and the undersize to a Biester-Overstrong concentrating table. The flotation plant consists of five cells, in which are used mixtures of oil of pine, pine tar, creosote, and coal tar. About 90 per cent of the ore is caught in the first two cells. From these the concentrate goes to Callow cones, where it is largely dewatered. Final drying is accomplished in filter presses, where the moisture is drawn off by compressed-air suction. A shipping product containing only 10 per cent of moisture is said to be produced.

DUNTON MINE.

The Dunton mine, the property of the Dunton Gold Mining Co., is on Harris Creek about 2 miles from the post office of Hollis, at the upper limit of high tide. Harris Creek is navigable for small boats at high tide up to the mine. This property lies at the south end of a zone of mineralization, which extends somewhat east of north for 4 or 5 miles, reaching some distance north of May-be-so Creek. The Dunton property includes two claims along this mineralized zone.

The country rock in this vicinity, according to Chapin,[9] consists of "a complex assemblage of igneous and sedimentary rocks. The bedded rocks include tuff, breccia, schist, limestone, black slate, argillite, and graywacke and are cut by a large boss of quartz diorite and associated porphyritic dikes." The country rock at the mine is a graphitic slate, which ranges in strike from east to N. 30° W., averaging perhaps N. 30° E., and dips 12°–35° SE. The slate is much faulted and slickensided, but the displacements are for the most part parallel with the rock structure. The highly graphitic character of the slate is particularly evident along the slickensided surfaces. Fine-grained dike rocks, in places porphyritic, also intrude the country rock more commonly parallel with the structure of the slate than otherwise.

The mineralized zone on which the Dunton mine is located extends about 2 miles to the northeast and then changes in trend or joins another zone which extends northward to May-be-so Creek. The northeastward-trending zone ends at the Hollis group of claims, and the northward-trending zone, which begins at that point, includes the Crackerjack and Ready Bullion lodes, to the north, although these

[9] Chapin, Theodore, Mining developments in the Ketchikan district, 1917: U. S. Geol. Survey Bull. 692, p. 87, 1919.

two lodes appear to be separate veins. According to Chapin[10] three veins, known as the lower, middle, and upper veins, are recognized at the surface in this mineralized zone. "These are approximately parallel and form a lode system following intrusive porphyry dikes." The vein that is mined at the Dunton mine is the upper vein. A 10-inch quartz seam lies 15 feet below this, and a barren quartz vein lies 150 feet lower.

The Dunton lode consists of a number of quartz stringers which form a mineralized zone in and conformable with the slate. The thickness averages about 7 feet, though increasing locally to 12 feet. The individual quartz stringers range in thickness from a few inches up to 1 or 2 feet. Much faulting has taken place parallel with the vein, crushing and slickensiding the ore and country rock but causing no apparent displacement. Dikes run parallel with the vein, more commonly on the hanging than on the footwall side, but here and there cutting across the lode. Many of these dikes are mineralized with pyrite, but they do not constitute minable ore. They have been greatly altered to secondary products, and the original petrographic character could not be inferred. The vein pitches on the average about 28° SE.

The quartz is mineralized by auriferous pyrite, gold, and a little galena. Good ore occurs in shoots, which appear to be localized in parts of the vein where the dip is lowest. The ore is best where pyrite is most abundant. Locally the slaty country rock carries some gold, particularly where it is pyritized. About 75 per cent of the gold is free, and the concentrates consist almost wholly of pyrite. Taken as a whole, the quartz and mineralized country rock, which together form the ore, would be classed as a low-grade gold ore, but only ore from the richer shoots is mined. This gives a higher-grade ore but limits the available tonnage.

The mine is developed by an adit 364 feet long, which follows down the dip of the vein. Four drifts—a short one at 70 feet, another at 100 feet, a third at 180 feet, and the fourth at 250 feet—constitute the chief development work. The ore is reduced by a 5-stamp Chalmers & Williams mill, with plates and concentrating table, operated by three vertical turbines generating together 90 horsepower. The mill has a capacity of 12 tons a day. Water is brought from Harris Creek through a 250-foot flume and delivered with a head of 13 feet.

[10] Chapin, Theodore, op. cit., p. 88.

NOTES ON THE SALMON-UNUK RIVER REGION.

Compiled by J. B. Mertie, Jr.

INTRODUCTION.

The Salmon-Unuk River region, in southeastern Alaska, is a trapeziform area of about 1,800 square miles, lying between parallels 55° 50′ and 56° 30′ north latitude and meridians 129° 50′ and 131° 10′ west longitude. The international boundary between Alaska and British Columbia, extending in a general northwesterly direction along the crest of the Coast Range, delimits the area on the northeast. This district is adjacent to tidewater, reaching Behm Canal on the southwest side and Portland Canal on the southeast side. On account of mining activity in the vicinity of Portland Canal, the southeastern part is referred to by Americans as the Portland Canal district and by Canadians as the Portland Canal mining division.

This portion of southeastern Alaska, along the international boundary and adjacent to the intrusive rocks on the Coast Range, has been recognized for years as favorable for the occurrence of mineral deposits, and in the last 22 years numerous more or less promising deposits have been discovered and located. The present renewal of public interest in this part of Alaska and British Columbia is due mainly to the recent successful development of some of these deposits at the head of Portland Canal, on the Canadian side of the boundary, and the promise which such development holds forth for the subsequent exploitation of similar deposits that lie along this same zone of mineralization.

A considerable amount of topographic and geologic work, both American and Canadian, has been done in this district and in the area adjoining it. The first and most essential preliminary requirement—that is, a topographic map—was prepared by the Canadian Boundary Commission in 1902, in connection with the accurate location of the international boundary; and in 1910 a topographic map of the Portland Canal mining area (map 50 A) was prepared by the Geological Survey of Canada. The later map covers mainly the area drained by Bear River, one of the headwater tributaries of Portland Canal. The accompanying base map (Pl. V) is compiled mainly from these two sources. A new map of this area is soon to be issued by the International Boundary Commission.

The principal publications by workers in the United States Geological Survey that have a bearing on the geology and mineralization of the Salmon-Unuk River district are as follows, named in chronologic order.

Brooks, A. H., Preliminary report on the Ketchikan mining district, Alaska: U. S. Geol. Survey Prof. Paper 1, 1902.

Wright, F. E., The Unuk River mining region of British Columbia: Canada Geol. Survey Summary Rept. for 1905, Ottawa, 1906.

Wright, F. E., and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, 1908.

Chapin, Theodore, Mining developments in southeastern Alaska in 1915: U. S. Geol. Survey Bull. 642, pp. 94–98, 1916.

The Skeena and Portland Canal mining divisions include that part of the Salmon-Unuk River region that lies in British Columbia. Notes on the progress of mining in these divisions have been published annually for a number of years by the British Columbia Bureau of Mines. The latest of these reports dealing with the valley of Salmon River are as follows:

Clothier, G. A., Portland Canal mining division: British Columbia Bur. Mines Ann. Rept. for 1917, pp. F68–F73, 1918.

Jack, P. S., Portland Canal mining division: Idem, p. F84.

Clothier, G. A., Portland Canal mining division: Idem for 1918, pp. K80–K83, 1919.

Investigations have also been carried on by the Geological Survey of Canada in these mining divisions, and this work is still in progress. Four reports have so far been published, and a fifth is in course of publication. The published reports are as follows:

McConnell, R. G., Portland Canal district, British Columbia: Canada Geol. Survey Summary Rept. for 1909, pp. 59–89, 1910.

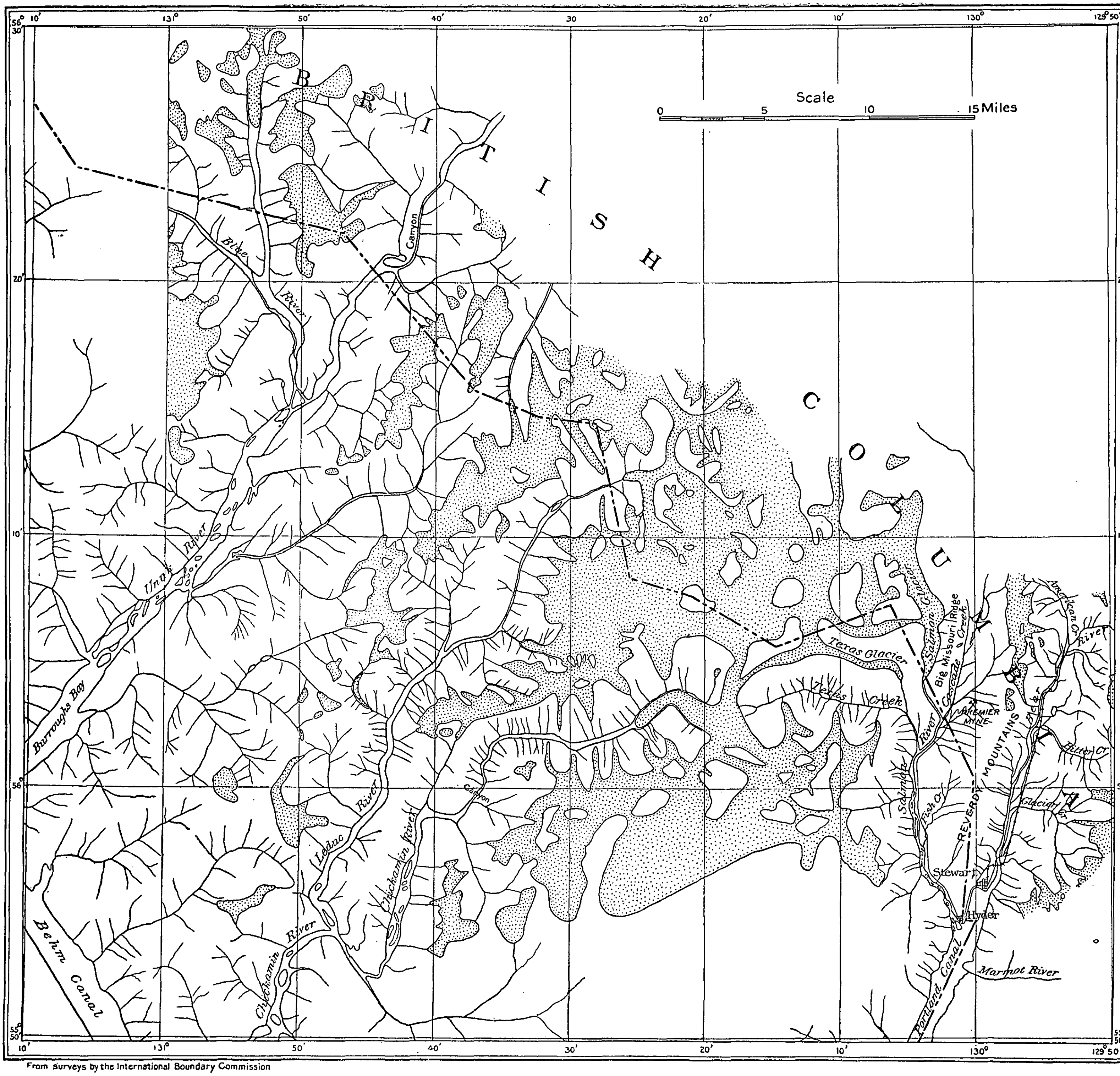
McConnell, R. G., Salmon River district, British Columbia: Idem for 1911, pp. 50–56, 1912.

McConnell, R. G., Portland Canal district, British Columbia: Idem, pp. 56–71.

McConnell, R. G., Portions of Portland Canal and Skeena mining divisions, Skeena districts, British Columbia: Canada Geol. Survey Mem. 32, 1913.

The last named of these four publications is essentially a compilation from the three earlier summary reports.

The present report represents no original work whatever on the part of the writer. It is essentially a brief compilation of the work of earlier American and Canadian workers, prepared to meet the demand for a statement of the available information on the area beginning at Portland Canal and extending northwestward. The only qualification of the writer for the preparation of such a statement is a general familiarity with the country gained by geologic field work in southeastern Alaska. The latest work by the United States Geological Survey was done in the Portland Canal district by Theodore Chapin in 1915, and his report is cited above.



From surveys by the International Boundary Commission

MAP OF SALMON-UNUK RIVER REGION.

PHYSICAL AND ECONOMIC GEOGRAPHY.

RELIEF.

The Salmon-Unuk River region belongs in large part to the Coast Range province of southeastern Alaska and is therefore an area of considerable relief. The area included in this report extends from tidewater at Behm and Portland canals to the crest of the Coast Range and therefore lies mainly in the western half of the Coast Range. The range in this area is about 100 miles wide and has rather poorly defined crest line. Many of the peaks of the range attain elevations of 6,000 to 9,000 feet, but within this area none exceed 8,000 feet. The mountain summits are more uniform in elevation in this western portion of the range, within the area of granitic rocks, than on the east side, where argillites and greenstones occur.

Some of the larger streams in this vicinity, such as Stikine, Nass, and Skeena rivers, cut completely through the Coast Range, and the smaller streams are in general deeply incised, resulting in the development of a marked relief. Thus Unuk River at the international boundary flows at an elevation of 600 feet above sea level, and a peak a short distance northwest rises to 6,200 feet. Similarly, Salmon and Bear rivers have their upper basins adjacent to mountains of 7,000 to 8,000 feet in elevation and reach tidewater within a distance of about 15 miles.

In addition to marked relief, this area is further characterized by very precipitous slopes, caused mainly by intense glaciation. The higher peaks are sharp and serrated, owing to crest-line sapping by the glaciers. Below 5,500 feet the hills were overridden by flowing ice and the crests are smooth and rounded, but the valley walls have been oversteepened by glacial scouring and are everywhere very precipitous and in places sheer, unscalable cliffs.

DRAINAGE.

The principal streams that drain this area, named in order from northwest to southeast, are Blue, Unuk, Leduc, Chickamin, Salmon, and Bear rivers. Of these, Blue River is tributary to the Unuk and Leduc River to the Chickamin. Unuk River enters Burroughs Bay, an inlet from Behm Canal, and Chickamin River enters Behm Canal. Salmon and Bear rivers enter Portland Canal at its head. Both Unuk and Chickamin rivers rise within the Coast Range and flow through more or less canyon-like valleys in their upper courses. In their lower courses, however, the valleys of these two streams broaden out and are characterized by wide, gravel-covered bottoms. At the head of Unuk River, about 60 miles from Burroughs Bay, a narrow divide leads over to a branch of Iskoot River, through the valley of which it is possible to enter the inland plateau of British Columbia.

Salmon and Bear rivers, though shorter than the Unuk and Chickamin, are of the same general character. Salmon River heads in Salmon Glacier and flows 13 miles to Portland Canal. Its principal tributaries are Texas Creek from the west and Cascade Creek from the north. Big Missouri Ridge, on which are some of the chief mining properties of the district, lies between Cascade Creek and Salmon Glacier, and Bear River Ridge is the divide between Bear and Salmon rivers.

Bear River is a swift mountain stream about 18 miles in length that enters the upper end of Portland Canal. It heads against Strohn Creek, a tributary of Nass River, in a low pass comparable with the pass at the head of Unuk River.

GLACIERS.

The upland areas of this region are covered with snow above an elevation of about 5,000 feet, and these snow fields form the reservoir or collecting ground for numerous glaciers that extend down into the valleys. At least one-fourth of the region here described is thus covered with snow and ice. The glaciers are of the valley or alpine type, and few of them extend far down into the valley bottoms. Practically all the major streams head against the terminals of these ice lobes. This present condition of alpine glaciation is an aftermath of the greater piedmont glaciers which at an earlier period covered all the mountains of this area and formed a continuous sheet of flowing ice that extended from sea level up to an elevation of about 5,500 feet.

CLIMATE.

This region has the characteristically wet climate of the western flank of the Coast Range, though the precipitation is not so great as at some other localities in southeastern Alaska, being probably about 100 inches a year. The summer climate is cool, with considerable rainfall, and the least precipitation occurs late in the spring and early in the summer. The winter climate is comparable with that of Juneau, and the thermometer seldom falls below zero. Snow falls in the valleys from November to March. Snowslides from the steep slopes are of common occurrence late in the winter and in the spring.

TIMBER AND VEGETATION.

The region is heavily forested up to an elevation of about 3,500 feet, and stunted timber grows in places 1,000 feet higher. In the valley bottoms, where the best timber is found for mining purposes, hemlock is the most abundant as well as the most valuable tree and furnishes good timber for mining and structural uses. Sitka spruce and cottonwood are also well represented in the valleys. Balsam and mountain hemlock are more abundant on the higher slopes. In addition to trees, a thick mantle of other vegetation, including moss and brush of several varieties, covers the bedrock exposures, except at high altitudes and on unscalable cliffs. This mantle makes prospecting difficult and accounts in part for the slow development of the mining resources.

WATER POWER.

Water powers should be available at many localities in this region, owing to the large size and steep gradients of the streams. In summer, as is the general rule in an area of high precipitation, with streams fed by melting snow and ice, water is usually plentiful. In winter, however, the supply is much less, for the precipitation is in the form of snow, and glacial melting is at a minimum. Careful measurements of the minimum run-off in winter should precede the establishment of power plants. Two power plants have already been established in Canadian territory, on Glacier and Lydden creeks, tributaries of Bear River.

SETTLEMENTS.

The two important settlements are Stewart and Hyder, the former in Canadian and the latter in American territory. Stewart, the distributing point for the Canadian part of the mining district, is at the head of Portland Canal, at the mouth of and on the west side of Bear River. It had a population of about 250 people in the fall of 1919. Hyder, the American distributing point, is about 2 miles from Stewart, at the mouth of and on the east side of Salmon River. In the fall of 1919 it was said to consist of 30 to 40 houses and was supplied with a wharf.

MEANS OF COMMUNICATION.

Hyder and Stewart, being on tidewater, are connected by steamship and gas-boat service with Prince Rupert and Ketchikan. A railroad starting from Stewart has been built up Bear River for a distance of about 12 miles, and a wagon road has also been constructed up the Bear River valley. Another wagon road has been built up the east side of Salmon River from Hyder for 11 miles, and a trail continues up onto the ridge between Salmon Glacier and Cascade Creek as far as the Big Missouri mine, a distance from Hyder of about 20 miles. A good wagon road has been built from Elevenmile up to the Premier mine, a distance of 5 miles. Another good road connecting Stewart and Hyder is nearing completion. During the summer of 1920 a road will probably be built from Elevenmile up Big Missouri Ridge. The Salmon River road is the only feasible means of egress from the Canadian mining properties along the west side of Bear River and on Big Missouri Ridge.

Another means of entrance to this region is by way of Unuk River. In 1905 a wagon road was built up Unuk River for a distance of 42 miles to a mining prospect, but portions of the road are now washed out.

GEOLOGY.

SALIENT FEATURES.

Little geologic work has been done in the American part of the Salmon-Unuk River region, chiefly because the rocks are mainly intrusive and afford little information regarding the geologic history of the region. On the Canadian side, however, a considerable amount of geologic study and mapping has been accomplished, chiefly by R. G. McConnell, of the Geological Survey of Canada, whose reports are listed on page 130. Subsequent work has been done by J. J. O'Neill, of the same organization, but the results of his investigations have not yet been published. The writer has merely compiled a condensed summary of the geology, so far as known at present.

The Coast Range batholith of granitic rocks is bordered on the east in the vicinity of Portland Canal by two series of sedimentary rocks, mainly of argillaceous character, between which lies a volcanic complex of massive and fragmental igneous rocks, usually of greenstone habit. All three of these formations are cut by intrusive rocks. At some localities Tertiary lavas are also present. Overlying the hard rocks are surficial deposits of alluvial, estuarine, and glacial origin. These six rock units, named in order from oldest to youngest, are the Bitter Creek formation, the Bear River formation, the Nass formation, the granitic rocks of the Coast Range, the Tertiary lavas, and the surficial deposits. The Bear River formation is a complex of volcanic rocks, in which has occurred the mineralization on Bear River and Big Missouri ridges, where mining developments are now progressing so rapidly.

BITTER CREEK FORMATION.

In the vicinity of Portland Canal the Bitter Creek formation is not known to occur west of Bear River, and therefore it will probably not be seen along the international boundary, where present mining interest centers. The formation consists mainly of argillite, which in places has developed a slaty cleavage, usually parallel with the original bedding planes. Some beds of much altered greenstone of tuffaceous origin and small nonpersistent beds of crystalline limestone are interstratified with the argillite at certain localities. This series of rocks as exposed east of Bear River dips southwestward under the other formations and is considered older. These rocks are either Paleozoic or Mesozoic; their exact age is not known. In the valleys of Glacier and Bitter creeks, eastern tributaries of Bear River, quartz veins and other mineralized zones are present in the Bitter Creek formation.

The upper 25 or 30 miles of Unuk River drains a schist-argillite belt, which begins about 4 miles upstream from the international boundary and is probably, at least in part, the equivalent of the Bitter Creek formation as known east of Bear River. It is likely that the schistose members in this belt have been developed by dynamic metamorphism caused by the intrusion of the Coast Range batholith. This belt of argillite appears to parallel the granite of the east from British Columbia to Skagway, and is characterized along its whole extent by the occurrence here and there of silver and gold bearing veins in the vicinity of the granitic rocks. Placer gold and lode deposits of silver, gold, and lead have been found in the upper valley of Unuk River, on the Canadian side of the boundary.

At least two narrow bands of schist cross Unuk River below the international boundary, and a somewhat wider band follows along the east side of Behm Canal. These schistose rocks are believed to represent metamorphosed phases of the sedimentary series of rocks east of the Coast Range batholith.

BEAR RIVER FORMATION.

Overlying the Bitter Creek formation is the Bear River formation, which crops out along the east side of Salmon River in Alaska and continues northeastward into British Columbia. This formation is the main country rock of the Salmon River valley, where a number of promising mining properties are situated. It is a complex made up chiefly of massive and tuffaceous volcanic rocks. The massive rocks are in general of andesitic nature and are called porphyrites. In general they are porphyritic, though this feature is not noticeable in all hand specimens, and they show a flow structure in many thin sections. Plagioclase feldspar in two generations is the chief constituent and is accompanied by subordinate amounts of augite or hornblende, iron oxides, and apatite. Secondary minerals, including chlorite, calcite, epidote, leucoxene, and hematite, are sufficiently common to impart to the rocks as a whole a greenstone habit. The fragmental rocks consist of tuff, volcanic breccias, and agglomerates and evidently indicate that sedimentation played a considerable part in the formation of this complex. This inference is further borne out by the presence of some thin intercalated beds of argillite.

Along the east side of Salmon Creek, in American territory, where this series of rocks abuts against the granite of the Coast Range, the greenstones are intensely sheared and metamorphosed and have developed into coarse greenish and grayish schists, in which the schistosity roughly parallels the greenstone-granite contact. The rocks dip steeply toward the granite, and in general the metamorphism increases in intensity in that direction.

NASS FORMATION.

Little need be said of the group of rocks that constitute the Nass formation, for they are not known to occur in Alaska and have not been found to be mineralized. Like the Bitter Creek formation, the Nass consists of a thick series of argillite, with some coarse clastic beds. In the upper Salmon River valley, within British Columbia, isolated bodies of such rocks overlie the Bear River formation.

GRANITIC ROCKS OF THE COAST RANGE.

The intrusive rocks that compose the Coast Range batholith range from granite to diorite and even to gabbro. Quartz-hornblende diorite, however, is the predominating type. The major part of the Salmon-Unuk River region is occupied by granitic rocks.

Within the central part of the granitic batholith the granite is of rather uniform texture, but at the edges, particularly along the west flank, variations are seen. Thus along the shores of Behm Canal pegmatite and aplite dikes form an intricate network of white strands at the edge of the granodiorite, and in the adjacent schist several generations of such dikes may be observed. At a distance this complex of granodiorite, schist, and dikes resembles a breccia. The granodiorite is also commonly gneissoid, and the included fragments of schist merge into rocks resembling basic differentiation products. As a result of this condition, brought about by intrusion at great depth, the contact between the granite and other country rock is indistinct in many places along the western flank of the batholith. This condition is less apparent along the eastern flank, although dike rocks are also present there.

The typical quartz-hornblende diorite of the Coast Range is composed essentially of plagioclase, feldspar, quartz, biotite, hornblende, and orthoclase, named in the order of abundance. Titanite, magnetite, and apatite are accessory minerals, and small amounts of secondary products such as epidote, sericite, calcite, and chlorite also occur in the central part of the batholith.

These granitic rocks are the source of the mineralizing solutions that have produced the ore deposits in this district, but the methods of formation of the deposits have been devious, and the resulting ores show wide differences in location, character, extent, and mineral content. It is noticeable, however, that important mineralization does not appear to have occurred within the main batholith but was confined to the edges of the granitic rocks and the adjacent sedimentary rocks. This is due to the fact that the mineralizing solutions found their easiest upward course along the fractured zones near the contact. The practical importance of this generalization is that the best hope of finding ore deposits on the American side of the Unuk-

Salmon River district is along the east side of Salmon River, where the Bear River formation occurs.

TERTIARY BASALT.

The Tertiary basalts of this region are gray-green to black porphyritic rocks ranging in composition from basic andesite to normal basalt, composed essentially of plagioclase, pyroxene, and magnetite, with a little olivine or quartz. Some alteration has taken place, but as a rule these rocks are very fresh in appearance. These beds of lava have been little disturbed since their formation and in most places lie almost horizontal. Some tuffaceous layers are interbedded with the lavas. Postglacial basaltic lavas are found in the lower valley of Blue River, just above its junction with the Unuk.

SURFICIAL DEPOSITS.

The surficial deposits are chiefly of three types, glacial, estuarine, and alluvial. The glacial deposits consist of till, glaciofluviatile material, and boulder clay, collected in deposits of many types. Estuarine deposits similar to those now being formed in the heads of the fiords are found on the hillsides at a height of 350 to 500 feet above the present sea level and point unmistakably to a postglacial uplift. Alluvial deposits composed of silt, sand, and gravel occur in the valleys and are due to aggradation by the present streams. Lacustrine deposits are also present in small areas.

MINERAL RESOURCES.

GENERAL LOCATION.

The mineralized zone of the Salmon-Unuk River region lies mainly along the east flank of the Coast Range granite batholith and is therefore largely in Canadian territory, except in the valley of Salmon River, at the head of Portland Canal. Prospecting and mining have been done at two general localities, one around the headwaters of Unuk River and the other at the head of Portland Canal, in the valleys of Salmon and Bear rivers. A zone of mineralization, however, lies along the east side of the granite batholith in British Columbia, and it is very likely that other mineral deposits will be found along this zone. It is significant that mineral deposits have been found at both the localities mentioned, which, as before pointed out, are the two natural passages through the range from the west in this particular district. The Portland Canal area is the more advantageously situated, for Portland Canal cuts completely through the granite and brings tidewater almost to the mines. The renewal of interest in mining in this district is due to the successful development of the Premier mine, and other properties of similar character in the upper valley of Salmon Creek. Most of these properties are on the Canadian side of the boundary, but it is not unlikely that others worth while will ultimately be located on the American side.

UNUK RIVER.

Placer gold was reported in the Canadian part of the Unuk Valley during the Cassiar excitement in the early seventies but received little attention. In the early eighties gold-bearing gravels were discovered on Sulphide Creek, and some placer gold was mined. Subsequent to the rush of 1898 lode deposits were located on Sulphide, Canon, and Bowlder creeks, tributaries of Unuk River, and on the North and South forks of the Unuk. On Sulphide Creek two quartz veins in particular were prospected—one a 2 to 8 inch vein of high-grade ore and the other a 20 to 30 foot vein of lower-grade ore. The high-grade ore from the narrow vein consisted chiefly of tetrahedrite (gray copper), pyrite, sphalerite, galena, and native silver. About 100 tons of ore from this vein was milled in a small stamp mill in 1901 and is reported to have given high assay returns, particularly in silver. The ore minerals of the other vein consisted of pyrite, galena, sphalerite, and chalcopyrite, with a little native gold in the oxidized parts of the vein. The remoteness of these lodes from the coast and the difficulties of access, even after a road was built up Unuk River, have caused a loss of interest in this mineralized area, and of late years no work has been done in this vicinity. It is admitted that a low-grade property would be of little value at that distance from the coast, but further prospecting along the east side of the granite batholith, north and south from Unuk River, with the purpose of locating lodes of high-grade ore, might be well worth while.

SALMON RIVER.

GEOGRAPHY.

Salmon and Bear rivers, at the head of Portland Canal, particularly the former, are the centers of the present mining interest in this district. Bear River flows entirely in British Columbia, but Salmon River lies partly in British Columbia and partly in Alaska. On this account, and because interest centers in this locality, only the conditions in the valley of Salmon River will be discussed here.

Salmon River rises in Salmon Glacier and flows about 13 miles to Portland Canal about 2 miles below Stewart. All of Salmon River proper lies in Alaska. Cascade and Texas creeks are the two important headwater tributaries. Cascade Creek rises in British Columbia and flows about 6 miles southward to join Salmon River about 2 miles below the glacier. Texas Creek lies entirely in Alaska, is about 10 miles in length, and flows in a general easterly direction to Salmon River about 4 miles below the glacier. The main ridge between Salmon and Bear rivers is known as Bear River Ridge, and the smaller ridge lying between Salmon Glacier and Cascade Creek is called Big Missouri Ridge. (See Pl. V.) The properties now under intensive development lie in the valley of Salmon River along the west side of Bear River Ridge and on Big Missouri Ridge.

AREAL GEOLOGY.

The country rock along the east side of Salmon River and Salmon River Glacier is mainly the andesitic greenstone of the Bear River formation. To the west lies the granite of the Coast Range. The contact between these two formations, however, is irregular and is marked by Salmon River only in the most general way. Isolated areas of granodiorite are present in the Bear River formation east of Salmon River and in fact are the immediate sites of a number of the ore deposits.

The greenstone near the granitic rocks is sheared and at places rendered schistose, the schistosity trending north and dipping toward the granite. The shearing and fissuring that are related to the ore deposition, however, cut transversely across the earlier structure, as may be seen at the Premier mine. Dike rocks of a variety of types, ranging from granite to more basic rocks, together with other intrusives of similar composition but of a fine-grained porphyritic character, are found in the Bear River formation. Some of these dikes are connected with the intrusion of the Coast Range batholith; others are no doubt more closely related to the andesitic greenstone sequence. It is presumed that the mineralization is connected with the intrusive igneous rocks of the Coast Range.

TYPES OF DEPOSITS.

Two general types of lode deposits may be found along the east side of the Coast Range batholith, within the Salmon–Unuk River region. These may be designated vein deposits and replacement deposits. The vein deposits consist of metallic minerals, usually with quartz, which have been laid down in open fractures, with a minimum of replacement of the country rocks. Where such deposits fill openings of regular form, such as openings along fault or joint planes, true veins are developed. Where the infiltration and deposition have occurred in irregularly fractured areas, something akin to a brecciated ore zone results. The replacement deposits are those which have been formed in zones of shearing and fissuring, with or without gangue minerals but accompanied by much replacement of the country rock. Naturally these two types are not mutually exclusive, and both types may be found in close association at some localities. It appears that the lodes along the east side of the Coast Range have been deposited at shallower depth than those along the west side, as at Juneau, and in contradistinction to the lodes of Kasaan Peninsula they show little or no evidence of contact-metamorphic origin.

Deposits of both the types mentioned are found in the Salmon River valley. The low-grade ores are chiefly impregnation and replacement deposits of considerable size lying along zones of fissuring and shearing. They are characterized by indistinct rather than sharp boundaries. The ore minerals are usually pyrite, sphalerite, galena, and chalcopyrite, and the valuable constituents are gold, silver, zinc, and to a smaller extent copper. Pyrrhotite is present at some localities, but it carries little gold, as the gold is apparently associated for the most part with pyrite. At and in the vicinity of these impregnated zones the country rock is much silicified and altered to calcite, chlorite, and sericite. In places the gangue material consists solely of such altered country rock. Considerable oxidation has taken place, as is indicated by the discoloration at the surface outcrops, and there is reason for the belief that downward enrichment may have played some part in the formation of some of the lodes.

The high-grade deposits are essentially rich silver and gold ores, occurring both as veins and as replacement deposits, many of them within zones of lower-grade ores. These higher-grade ores have not been studied in detail, and their exact relation to the lower-grade ores is not definitely understood, though the evidence available points to their formation at a somewhat later period. The silver minerals present in the high-grade ores include argentite (silver glance), argentiferous tetrahedrite, native silver, pyrargyrite, and proustite, and possibly stephanite and other silver minerals. Little native gold is seen, and ores with high gold content are characterized by much pyrite.

LODE PROPERTIES.

The properties at present being prospected or developed include the Premier, Mineral Hill, Big Missouri, Bush mines, Forty-Nine, Indian mines, International, Payroll, Yellowstone, Boundary, Northern Light, Cascade Forks, Spider, Hercules, Silver Tip, Bunting, Unicorn, Lake & O'Leary, New Alaska, Knobhill, and other groups of claims. All these are in British Columbia. The International, Premier, Bunting, and Bush mines properties lie along the west flank of Bear River Ridge, but the Indian, Boundary, Payroll, Mineral Hill, Big Missouri, Hercules, Forty-Nine, and Yellowstone groups of claims stretch northward up Big Missouri Ridge.

The Premier mine is at present considered the most promising of these properties. A description of the history and development of this mine is given by Charles Bunting.[1] This property, which originally consisted of two claims, lies along the west side of Bear River Ridge and was discovered and staked in June, 1910. These and adjoining claims later passed into the hands of O. B. Bush, who organized the Salmon-Bear River Mining Co. This company and others to which the property was successively bonded carried on development work until the spring of 1919, when the potentialities of the property were finally recognized and demonstrated by R. K. Neill, of Spokane. Partial ownership and financial control have now passed into the hands of the American Smelting & Refining Co.

The lode is reported to consist of three low-grade ore bodies and one of high grade, which appear to be of the replacement type above described. The country rock is the Bear River formation, or andesitic greenstone, greatly sheared, fissured, and fractured. The high-grade deposit, on which the most work has been done, is an ore zone in the fractured porphyry and follows a shear zone of fissuring and fracturing which strikes N. 80° E. and dips 60° S. The gangue is chiefly the silicified country rock. The ore minerals are reported to be argentite (silver glance), argentiferous tetrahedrite, stephanite (brittle silver), pyrargyrite, proustite, native silver, and pyrite carrying much gold. A little pyrrhotite is present, but it carries only a small percentage of gold. Small stringers in the larger ore body are reported to carry wonderful specimens of the silver minerals. Though classed as a rich silver mine, the ore is valuable for both gold and silver, the latter predominating. A sampling of all the present workings and openings is reported by Bunting to have given an average value well over $30 a ton in silver and gold. The 512 tons that has so far been shipped gave smelter returns of $168,000.

Less is known as yet of the possibilities of the low-grade deposits on the Premier property, but it is assumed that like other low-grade deposits near by, they consist of silicified zones in the andesitic greenstone, impregnated with sulphides, chiefly pyrite, galena, sphalerite, and chalcopyrite, carrying both gold and silver.

The big Missouri, Mineral Hill, and Bush properties are also being developed.

With regard to mining properties in the Alaska portion of the Salmon River valley the following notes by Chapin[2] give some idea of what had been accomplished up to 1915:

A group of claims extending from Sevenmile, on Salmon River, to Fish Creek, has been located, but only two of them have been developed. On the Riverside claim a tunnel 100 feet above the river flat has been driven for 140 feet along a strong fissure vein. The vein averages about 4 feet in width but pinches to 18 inches and in places widens to 6 feet. Both walls are well defined. The wall rock is somewhat

[1] Bunting, Charles, The Premier gold mine, Portland Canal, British Columbia: Min. and Sci. Press, Nov. 8, 1919, pp. 670-672.

[2] Chapin, Theodore, Mining developments in southeastern Alaska, 1915: U. S. Geol. Survey Bull. 642, pp. 97-98, 1916.

altered but contains little gouge. The vein filling is quartz with abundant sulphides. Pyrite is the most abundant along the hanging wall and occurs in solid bunches and in disseminated particles associated with chalcopyrite. On the footwall galena is the most plentiful sulphide. The country rock is crystalline schist. On a parallel lode of much the same character the Riverview claim is being developed. The vein strikes N. 60° W. and dips about 60° NE. An adit has been driven for 17 feet, exposing a vein that varies from 1 foot to 4 feet in width. At the mouth of the opening it is 2 feet wide on the roof and widens to 4 feet on the floor of the adit. At the face it is from 12 to 18 inches in width. Although the vein swells and narrows from place to place, the walls are well defined.

At Elevenmile a little prospecting has been done, and several claims have been located. On the Elevenmile and Iron claims a number of open pits have exposed an iron-stained lode that follows a brecciated zone filled with veins of quartz carrying chalcopyrite, sphalerite, and galena. Stringers of sulphide form shoots of very rich ore with high silver content. On the Iron claim a ton of this high-grade ore has been sacked ready for shipment. The lode strikes northeast and dips steeply northwest. On the hillside above Elevenmile, at an altitude of 1,500 feet, the Bertha and Western claims are being developed on a northeastward-trending lode. One surface cut shows the lode to be at least 15 feet in width. It consists of silicified schistose green tuff of the "Bear River formation," with disseminated pyrite, chalcopyrite, galena, and sphalerite. A number of claims have been staked on a zone of disseminated deposits exposed along Salmon River at Eightmile and Ninemile, but only a little work has been done.

Some promising fissure lodes have been located by Murphy & Stevenson on Fish Creek and its tributary, Skookum Creek, where more than the necessary amount of assessment work has been done. Near the mouth of Skookum Creek an adit was driven for 25 feet along a fissure that had been traced by surface trenches for 2,000 feet The vein is 4½ feet wide, strikes N. 40° E., and dips about 55° SE. The quartz gangue carries galena, chalcopyrite, tetrahedrite, sphalerite, and pyrite in veinlets and irregular patches. It is being exploited mainly for its gold and silver content.

Near the head of Skookum Creek, at an altitude of 1,600 feet, a fissure vein has been opened by an adit 320 feet in length and several crosscuts and inclines. The gangue is quartz. Metallic sulphides present are tetrahedrite, chalcopyrite, galena, sphalerite, and pyrite in blebs and veinlets penetrating the quartz, and the richest ore occurs in veinlets of tetrahedrite and galena. The country rock is porphyry and schistose tuff of the "Bear River formation." The lode strikes N. 55° W. and dips 45° SW. At the portal it is about 18 inches wide. At 70 feet from the portal only a part of the vein is exposed, as the ore has been removed to a wall within the vein. At this place the vein is 3 feet wide plus an unknown width in the wall of the adit. At various places portions of the vein said to be very rich have been stoped out. At 300 feet from the adit mouth the lode is abruptly cut by a vertical fault trending nearly perpendicular to the lode, and short drifts along the fault plane in both directions had not shown the position of the faulted lode. Samples of ore said to come from a near-by prospect, which was not visited, contain particles of free gold in siliceous gangue.

Several claims have been staked on Texas Creek. The ore bodies are reported to be quartz veins carrying seams of tetrahedrite penetrating granite and pegmatite. Little work has been done in this locality.

WATER-POWER INVESTIGATIONS IN SOUTHEASTERN ALASKA.[1]

By George H. Canfield.

INTRODUCTION.

Systematic investigation of the water resources of Alaska was begun by the United States Geological Survey in 1906 and has been carried on in different parts of the Territory to the present time. This investigation was undertaken in response to the need for definite information in regard to water available for many uses, among which the most important are hydraulicking, dredging, and supplying power for mines, canneries, and sawmills.

The investigation of the water resources of southeastern Alaska was begun by the Geological Survey in cooperation with the Forest Service in 1915 and was designed to determine both the location and the possibilities of water-power sites. The results of previous years' work have already been published.[2] A table showing water-power possibilities in southeastern Alaska is given on page 184.

The Geological Survey maintained a number of gaging stations in southeastern Alaska throughout the year, and other stations were installed in cooperation with individuals and corporations. The records obtained at these stations are contained in this paper. Acknowledgment is made to those who have assisted in this work, particularly to Mr. W. G. Weigle and Mr. Charles H. Flory, supervisors of the Forest Service at Ketchikan, and to Mr. Philip H. Dater, district engineer at Portland, Oreg.

The stations for which the records are presented are the following:

Myrtle Creek at Niblack.
Ketchikan Creek at Ketchikan.
Fish Creek near Sealevel.
Swan Lake outlet at Carroll Inlet.
Orchard Lake outlet at Shrimp Bay.
Shelockum Lake outlet at Bailey Bay.
Karta River at Karta Bay.
Cascade Creek at Thomas Bay.
Green Lake outlet at Silver Bay.

[1] In cooperation with the United States Forest Service.
[2] U. S. Geol. Survey Bull. 662, pp. 100-154, 1918; Bull. 692, pp. 43-83, 1919.

Baranof Lake outlet at Baranof.
Sweetheart Falls Creek near Snettisham.
Crater Lake outlet at Speel River, Port Snettisham.
Long River below Second Lake, at Port Snettisham.
Grindstone Creek at Taku Inlet.
Carlson Creek at Sunny Cove.
Sheep Creek near Thane.
Gold Creek at Juneau.
Falls Creek at Nickel.
Porcupine Creek near Nickel.

STATION RECORDS.

MYRTLE CREEK AT NIBLACK, PRINCE OF WALES ISLAND.

LOCATION.—Halfway between beach and Myrtle Lake outlet, which is one-third mile from tidewater, 1 mile from Niblack, in north arm of Moira Sound, Prince of Wales Island, and 35 miles by water from Ketchikan.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—July 30, 1917, to December 31, 1919.

GAGE.—Stevens continuous water-stage recorder on right bank; reached by a trail which leaves beach near the mouth of the creek.

DISCHARGE MEASUREMENTS.—At medium and high stages made from a cable across creek at outlet of lake; at low stages made by wading.

CHANNEL AND CONTROL.—The gage is in a pool 10 feet upstream from a contracted portion of the channel, at a rocky riffle that forms a well-defined and permanent control. At the cable section the bed is smooth, the water deep, and the current uniform and sluggish.

EXTREMES OF DISCHARGE.—Maximum stage during year from water-stage recorder, 3.07 feet at 9 a. m. December 18 (discharge, 196 second-feet); minimum stage 1.08 feet, September 8–9 (discharge, 28 second-feet).

1917–1919: Maximum stage recorded, 4.40 feet at 5 p. m. November 18, 1917; discharge, estimated from extension of rating curve, 387 second-feet; minimum stage, 1.08 feet September 8–9, 1919 (discharge, 28 second-feet).

ICE.—Stage-discharge relation not affected by ice.

ACCURACY.—Stage-discharge relation permanent. Rating curve, determined by five discharge measurements, is very well defined between 30 and 220 second-feet. Operation of water-stage recorder satisfactory except for periods shown in footnote to daily-discharge table. Daily discharge ascertained for periods recorder was operating by applying to rating table mean daily gage height; for periods recorder was not operating by determining with a planimeter the monthly means from an estimated hydrograph drawn by means of staff gage readings by observer about once every 10 days, maximum and minimum stages indicated by the recorder, and recorded hydrograph, and by comparison of the record for this station with that for Karta River. Records good except for periods when the recorder stopped, for which they are fair.

Myrtle Lake, the outlet of which is 800 feet from Niblack Anchorage, is 95 feet above sea level and covers 122 acres. Niblack Lake, the outlet of which is 5,700 feet from Niblack Anchorage, is 450 feet above sea level and covers 383 acres. Mary Lake, unsurveyed, is about 600 feet above sea level and is a mile long and one-fourth to one-half mile wide. The large lake area in this small drainage basin is the cause of the well-maintained flow during the winter and periods of little rainfall.

The following discharge measurement was made by G. H. Canfield:

August 29, 1919: Gage height, 1.20 feet; discharge, 32 second-feet.

Daily discharge, in second-feet, of Myrtle Creek at Niblack for 1919.

Day.	Jan.	Feb.	Mar.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	79	....	44	....	49	39	31	33	50	48
2	96	....	42	....	48	39	30	33	46	46
3	99	....	42	....	48	39	29	34	....	45
4	157	56	43	....	52	38	29	33	....	44
5	134	52	44	....	51	37	29	33	....	43
6	146	52	43	....	49	37	30	35	....	42
7	200	51	42	....	50	36	29	46	....	42
8	213	63	41	....	72	36	29	40	....	41
9	220	77	41	....	67	35	28	37	....	40
10	220	100	39	....	58	35	28	56	....	39
11	194	84	38	....	58	34	29	54	....	38
12	175	73	38	....	78	34	35	50	....	36
13	194	79	37	....	82	35	44	47	....	36
14	163	73	37	....	85	35	38	46	57	36
15	140	68	36	....	75	39	34	....	63	42
16	127	88	35	....	68	50	32	....	64	76
17	112	91	35	....	64	45	58	....	88	105
18	105	100	34	....	60	40	77	....	94	175
19	92	100	....	....	57	44	76	50	77	125
20	84	85	....	....	55	64	58	48	118	92
21	....	73	....	....	52	52	60	....	102	79
22	....	66	....	....	51	45	63	....	84	116
23	....	60	....	....	49	39	53	....	88	134
24	....	57	....	....	48	36	46	....	73	120
25	....	54	....	....	47	35	44	33	64	....
26	....	52	....	....	45	34	40	....	58	....
27	....	48	....	55	44	33	38	....	58	....
28	....	47	....	53	43	33	36	....	56	....
29	....	....	....	52	42	33	35	....	53	....
30	....	....	....	50	41	33	35	47	50	....
31	....	....	....	....	41	32	....	53	....	....

NOTE.—Discharge for following periods estimated because of unsatisfactory operation of water-stage recorder, from maximum and minimum stages indicated by recorder and by comparison with hydrograph for Karta River: Jan. 21–31, 80 second-feet; Feb. 1–3, 65 second-feet; Mar. 19–31, 60 second-feet; Apr. 1–31, 100 second-feet; May 1–31, 110 second-feet; June 1–26, 90 second-feet; Dec. 25–31, 115 second-feet. Discharge for following periods estimated from records for Karta River: Oct. 15–18, 40 second-feet; Oct. 21–24, 35 second-feet; Oct. 26–29, 35 second-feet; Nov. 3–13, 40 second-feet.

Monthly discharge of Myrtle Creek at Niblack for 1919.

Month.	Discharge in second-feet.			Run-off (in acre-feet).
	Maximum.	Minimum.	Mean.	
January	220	....	124	7,620
February	100	47	69.4	3,850
March	61	34	48.1	2,960
April	....	....	100	5,950
May	....	....	110	6,760
June	....	50	85.0	5,060
July	85	41	55.8	3,430
August	64	32	38.6	2,370
September	77	28	40.8	2,430
October	56	33	40.3	2,480
November	118	....	59.4	3,530
December	175	36	78.9	4,850
The year	220	28	70.8	51,300

KETCHIKAN CREEK AT KETCHIKAN.

LOCATION.—One-fourth mile below power house of Citizens Light, Power & Water Co. one-third mile northeast of Ketchikan post office, downstream 200 feet from mouth of Schoenbar Creek (entering from right), 1¼ miles from mouth of Granite Basin Creek (entering from left), and 1½ miles from outlet of Ketchikan Lake.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—November 1, 1909, to June 30, 1912; June 9, 1915, to December 17, 1919.

GAGE.—Vertical staff fastened to a telephone pole near board walk on left bank at bend of creek 200 feet downstream from mouth of Schoenbar Creek; read by employee of the Citizens Light, Power & Water Co. The gage used since June 9, 1915, consisted of the standard United States Geological Survey enameled gage section graduated in hundredths, half-tenths, and tenths from zero to 10 feet. The original gage, established November, 1909, and read until June 30, 1912, is at same location and same datum. It is a staff with graduations painted every tenth. Gage not replaced when a new telephone pole was placed December 17, 1919, by the company.

DISCHARGE MEASUREMENTS.—At medium and high stages from footbridge about 500 feet upstream from gage; measuring section poor, as the bridge makes an angle of 20° with the current, and at high stages the flow is broken by large stumps near left bank and at middle of bridge. Low-stage measurements made by wading 50 feet below bridge or at another section 100 feet above gage. The flow of Schoenbar Creek has been added to obtain total flow past gage.

CHANNEL AND CONTROL.—Gage is located in a large deep pool of still water at a bend in creek. The bed of the stream at the outlet of this pool is a solid rock ledge, but changes in a gravel bar at lower right side of pool cause occasional changes in stage-discharge relation.

EXTREMES OF DISCHARGE.—1909–1912 and 1915–1919: Maximum stage recorded, 8.3 feet November 18, 1917 (discharge estimated from extension of rating curve, 4,400 second-feet); minimum discharge, 34 second-feet, September 24, 1915.

ICE.—Ice forms along banks but control remains open.

DIVERSIONS.—A small quantity of water is diverted above the station for the use of the town of Ketchikan, the New England Fish Co., and the Standard Oil Co.

REGULATION.—Small timber dam and headgates are located at outlet of Ketchikan Lake. Water diverted through power house is returned to creek above gage but causes very little diurnal fluctuation. During low water the flow is increased by water from the reservoir.

ACCURACY.—Stage-discharge relation changed during high water August 19, 1917. Rating curve used August 19, 1917, to December 17, 1919, fairly well defined below and poorly defined above 800 second-feet. Gage read to hundredths once daily. Daily discharge ascertained by applying gage height to rating table.

The following discharge measurement was made by G. H. Canfield:

February 27, 1919: Gage height, 0.18 foot; discharge, 49 second-feet.

Daily discharge, in second-feet, of Ketchikan Creek at Ketchikan for 1917–1919.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1917.												
1	118	61	54	42	125	228	720	180	110	180	2,370	95
2	69	54	54	42	93	196	382	200	110	450	1,778	83
3	71	54	61	245	90	196	493	160	95	466	450	72
4	66	108	66	241	74	196	720	180	95	295	295	55
5	64	176	69	125	76	220	616	160	95	1,150	230	67
6	74	249	66	99	160	308	357	160	95	410	1,530	80
7	142	232	61	82	160	216	382	160	89	230	3,930	160
8	262	285	54	79	523	436	285	160	80	160	1,200	570
9	87	212	50	76	285	262	180	142	80	144	450	160
10	262	216	50	76	220	196	160	241	80	125	700	95
11	276	168	52	71	216	200	160	142	95	295	490	67
12	115	125	54	76	220	204	142	125	104	230	370	55
13	82	523	52	76	212	204	142	108	110	180	2,950	55
14	79	450	48	64	200	204	142	160	140	160	4,000	55
15	74	740	44	64	180	204	142	285	205	180	1,350	55
16	64	377	44	64	180	196	139	241	225	180	490	55
17	66	180	66	66	180	204	139	332	160	180	1,250	55
18	66	118	61	90	285	553	142	1,290	180	180	4,400	55
19	85	108	54	142	220	493	142	31,60	140	160	2,310	53
20	74	69	61	176	200	332	125	1,530	110	295	950	53
21	61	66	54	142	180	382	125	530	110	330	530	51
22	64	66	71	139	172	357	125	1,890	110	750	230	45
23	102	64	69	142	160	220	125	450	107	700	230	45
24	142	64	56	142	176	220	285	260	107	260	450	45
25	204	61	54	142	180	180	155	205	205	230	490	45
26	125	61	54	142	176	180	125	200	119	260	370	45
27	122	64	44	142	180	180	180	295	205	230	750	43
28	90	54	44	139	180	160	142	530	295	410	295	45
29	66	....	46	142	216	160	142	230	378	260	160	210
30	64	....	44	139	220	180	142	205	354	900	116	260
31	61	....	42	....	220	....	180	195	....	2,490	....	230
1918.												
1	205	60	55	55	144	152	180	140	77	67	800	850
2	630	55	55	60	316	125	164	134	75	95	370	700
3	260	450	53	75	410	125	148	110	67	152	140	470
4	570	230	45	80	410	122	125	67	67	1,590	116	122
5	230	148	45	62	370	95	125	104	65	1,530	180	80
6	180	119	43	53	390	86	128	62	62	470	650	53
7	125	116	43	60	370	75	131	570	55	309	390	116
8	45	95	43	89	260	67	125	510	55	800	288	104
9	45	134	43	180	242	60	119	450	53	370	160	86
10	55	119	43	92	230	110	125	330	67	323	122	67
11	86	110	43	110	220	160	95	180	65	1,770	80	64
12	89	80	43	110	205	168	119	160	55	490	134	52
13	86	67	45	119	205	180	95	80	55	330	288	53
14	65	60	45	125	172	205	89	72	53	316	225	263
15	89	55	45	134	160	205	101	75	45	230	122	230 0
16	83	53	45	125	180	200	86	89	53	248	134	230
17	230	53	45	119	205	200	80	92	260	610	92	281
18	309	51	45	260	205	172	80	89	205	205	67	295
19	144	45	45	402	215	160	80	122	67	370	65	230
20	110	45	45	330	225	160	77	260	53	725	67	110
21	89	45	80	316	230	156	75	205	53	312	410	104
22	254	45	53	323	160	152	75	675	53	140	230	92
23	260	45	55	260	148	152	75	510	95	119	248	160
24	274	45	75	160	125	152	72	295	65	122	370	134
25	131	43	77	152	122	160	92	205	260	92	410	610
26	110	43	67	148	110	172	104	180	125	900	370	1,000
27	119	45	75	131	110	160	530	650	62	390	288	260
28	101	67	80	131	330	125	530	288	55	370	750	125
29	80	....	89	140	205	125	200	295	55	281	1,950	101
30	60	....	62	172	200	152	148	137	53	330	1,200	67
31	55	....	55	....	176	....	180	125	....	825	....	55

Daily discharge in second-feet, of Ketchikan Creek at Ketchikan for 1917–1919.—Contd.

Day	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1919.												
1	80	67	55	950	152	205	144	89	67	67	370	65
2	410	60	53	700	122	200	125	80	67	62	230	62
3	260	55	55	390	110	180	116	80	65	77	140	67
4	1,000	55	53	260	104	172	148	77	65	80	67	55
5	610	67	53	248	92	160	110	77	67	80	67	62
6	410	55	53	180	83	160	104	75	65	410	65	67
7	630	60	51	168	80	152	95	77	62	110	62	62
8	950	205	53	370	119	140	110	80	62	101	92	60
9	610	168	55	110	125	140	107	77	60	160	80	62
10	370	140	60	92	140	152	116	77	67	80	67	60
11	370	125	55	140	160	160	118	80	67	205	89	62
12	230	119	53	92	180	152	110	83	89	125	450	60
13	140	110	53	92	160	131	230	168	67	110	370	62
14	119	86	53	95	295	134	370	172	67	101	370	67
15	104	67	55	89	610	134	260	610	65	89	570	230
16	86	116	53	95	530	128	152	172	67	122	1,100	700
17	67	110	53	89	230	125	390	110	1,650	77	1,590	630
18	67	230	53	95	470	125	110	101	1,100	67	1,410	....
19	65	110	53	95	725	152	116	134	750	72	1,350	....
20	62	75	62	370	610	248	107	725	570	75	1,150	....
21	67	72	83	323	281	267	113	205	1,100	75	750	....
22	110	67	95	570	180	458	98	125	800	67	570	....
23	101	65	89	295	195	570	110	101	205	67	390	....
24	80	62	86	220	248	394	95	95	180	65	230	....
25	72	62	53	172	260	180	101	80	134	65	125	....
26	80	60	53	650	281	205	98	70	110	72	116	....
27	80	55	62	750	230	180	98	75	89	80	95	....
28	74	55	86	634	220	160	104	75	80	72	67	....
29	180	....	195	295	140	152	101	72	67	67	67	....
30	110	....	650	180	122	140	107	67	67	225	67	....
31	75	....	530	....	116	....	95	80	....	205	....	....

Monthly discharge of Ketchikan Creek at Ketchikan for 1917–1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1917.				
January	267	61	106	6,520
February	740	54	179	9,940
March	71	42	54.8	3,370
April	245	42	114	6,780
May	523	74	192	11,800
June	553	160	249	14,800
July	720	125	240	14,800
August	3,160	108	455	28,000
September	378	80	146	8,690
October	2,490	125	402	24,700
November	4,400	116	1,170	69,600
December	570	43	99	6,090
The year	4,400	42	283	205,000
1918.				
January	630	45	167	10,300
February	450	43	90.1	5,000
March	89	43	54.3	3,340
April	402	53	152	9,040
May	410	110	227	14,000
June	205	60	144	8,570
July	530	72	140	8,610
August	675	62	234	14,400
September	260	45	81.0	4,820
October	1,770	67	480	29,500
November	1,950	65	357	21,200
December	1,000	53	231	14,200
The year	1,950	43	198	143,000

Monthly ischarge of Ketchikan Creek at Ketchikan for 1917-1919—Continued.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
1919.				
January	1,000	62	247	15,200
February	230	55	92.1	5,120
March	650	51	98.9	6,080
April	950	89	294	17,500
May	725	80	238	14,600
June	570	125	195	11,600
July	390	95	137	8,420
August	725	67	135	8,300
September	1,650	60	266	15,800
October	410	62	107	6,580
November	1,590	62	406	24,200
December 1-17	700	55	143	4,820
The year				138,000

FISH CREEK NEAR SEALEVEL, REVILLAGIGEDO ISLAND.

LOCATION.—In latitude 55° 24′ W., near outlet of Lower Lake on Fish Creek, 600 feet from tidewater at head of Thorne Arm, 2 miles northwest of mine at Sealevel, and 25 miles by water from Ketchikan.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—May 19, 1915, to December 31, 1919.

GAGE.—Stevens water-stage recorder on right shore of Lower Lake, 200 feet above outlet.

DISCHARGE MEASUREMENTS.—At medium and high stages made from cable across creek, 1 mile upstream from gage and 500 feet above head of Lower Lake; at low stages made by wading at cable. Only one small creek enters Lower Lake, at point opposite gage, between the cable site and control.

CHANNEL AND CONTROL.—The lake is about 500 feet wide opposite the gage. Outlet consists of two channels, each about 60 feet wide, separated by an island 40 feet wide. From the lake to tidewater, 200 feet, the creek falls about 20 feet. Bedrock exposed at the outlet of the lake forms a well-defined and permanent control.

EXTREMES OF DISCHARGE.—Maximum stage during year from water-stage recorder 4.78 feet at 11 p. m., December 18 (discharge computed from an extension of rating curve, 3,810 second-feet); minimum stage, 0.63 foot, March 19 (discharge, 40 second-feet).

1915–1919: Maximum stage recorded, 5.33 feet November 1, 1917 (discharge, 4,600 second-feet); minimum stage, 0.50 foot, February 11, 1916 (discharge, 22 second-feet).

ICE.—Lower Lake freezes over, but as gage is set back in the bank ice does not form in well, and the relatively warm water from the lake and the swift current keep the control open.

ACCURACY.—Stage-discharge relation permanent. Rating curve well defined below and extended above 1,500 second-feet. Operation of water-stage recorder satisfactory except for period indicated by break in record shown in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of day. Records good, except for short period of break in record, for which they are fair.

There are three large lakes in the upper drainage basin. Big Lake, 2 miles from beach at an elevation of 275 feet, covers 1,700 acres; Third Lake, 250 acres; and Mirror Lake, at an elevation of 1,000 feet, 800 acres. Two-thirds of the drainage basin is covered with a thick growth of timber and brush interspersed with occasional patches of beaver swamp and muskeg. Only the tops of the highest mountains are bare. This large area of lake surface and vegetation, notwithstanding the steep slopes and shallow soil, affords a little ground storage and after a heavy precipitation maintains a good run-off. During a dry, hot period in summer, however, after the snow has melted, the flow becomes very low because of lack of ice or glaciers in the drainage basin.

No discharge measurements were made at this station during the year.

Daily discharge, in second-feet, of Fish Creek near Sealevel for 1919.

Day.	Jan.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	157	65	1,960	539	351	312	172	116	132	228	139
2	153	62	1,620	421	395	285	168	106	116	238	116
3	188	60	1,100	329	512	280	164	98	119	210	106
4	790	58	806	285	595	351	157	89	202		
5	1,200	56	726	259	512	466	157	84	296		
6	965	56	595	254	428	460	168	84	324		
7	1,690	55	473	285	368	408	168	80	408		
8	1,960	53	378	351	330	356	161	78	546		
9	1,560	55	334	408	345	329	149	73	492		
10	1,060	56	285	402	395	302	142	69	408	104	
11	790	56	280	378	408	296	132	69	402	104	
12	560	51	285	368	384	285	123	69	460	94	
13	492	50	275	362	356	296	116	80	460	123	
14	368	48	243	378	351	340	132	123	356	307	50
15	296	50	233	492	345	384	285	129	275	525	51
16	249	48		610	351	378	539	142	220	766	123
17	197	45		595	345	351	492	210	176	1,070	470
18	172	42		512	351	324	395	710	149	1,960	3,110
19	161	40		595	368	296	368	983	142	1,840	2,940
20	136	45		920	492	275	866	938	312	1,460	1,460
21	126	60		875	610	254	806	655	460	1,200	806
22		94		632	560	243	539	648	506	875	553
23		126		506	567	238	378	595	460	710	595
24		123	312	610	610	224	275	447	340	553	625
25		111	312	830	539	220	210	351	259	408	
26		104	525	790	440	220	168	307	206	312	
27		91	947	686	434	210	149	259	168	259	
28		157	938	610	395	210	132	210	161	228	1,060
29		312	875	506	362	206	116	172	168	197	734
30		1,010	670	460	340	202	116	153	176	165	492
31		1,620		384		188	123		224		346

NOTE.—Discharge for following periods estimated, because of unsatisfactory operation of water-stage recorder, from maximum and minimum stages indicated by recorder and by comparison with hydrographs of other stations: Jan. 22–31, 140 second-feet; Feb. 1–28, 155 second-feet; Apr. 16–23, 320 second-feet; June 8 and 9, as shown in table; Nov. 4–9, 120 second-feet; Dec. 4–13, 70 second-feet; and Dec. 25–27, 1,100 second-feet.

Monthly discharge of Fish Creek near Sealevel for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	1,960		473	29,100
February			155	8,610
March	1,620	40	157	9,650
April	1,960		558	33,200
May	920	254	504	31,000
June	610	330	428	25,500
July	466	188	296	18,200
August	866	116	260	16,000
September	983	69	271	16,100
October	546	116	294	18,100
November	1,960		489	29,100
December	3,110		573	35,200
The year	3,110	40	373	270,000

SWAN LAKE OUTLET AT CARROLL INLET, REVILLAGIGEDO ISLAND.

LOCATION.—Halfway between Swan Lake and tidewater, on east shore of Carroll Inlet 1 mile from its head, 30 miles by water from Ketchikan.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—August 24, 1916, to December 31, 1919.

GAGE.—Stevens water-stage recorder on left bank, half a mile from tidewater; reached by a trail which leaves beach back of old cabin one-fourth mile south of mouth of creek. Gage was washed out by extreme high water in November, 1917. New gage installed 10 feet farther back in bank at old datum, but with a new control, on May 5, 1918.

DISCHARGE MEASUREMENTS.—At medium and high stages, made from a cable across stream 100 feet downstream from gage; at low stages, made by wading.

CHANNEL AND CONTROL.—The gage well is in a deep pool 25 feet upstream from a contracted portion of the channel, where a fall of 1 foot over bedrock forms a permanent control. The effect of the violent fluctuation of the water surface outside of the gage well is decreased in the inner float well, because the intake holes at the bottom are very small. At the cable section the bed is rough, the water shallow, and the current very swift. Point of zero flow is at gage height −1.0 foot.

EXTREMES OF DISCHARGE.—Maximum stage during year, from water-stage recorder, 6.55 feet at 10 a. m., December 18 (discharge, computed from extension of rating curve, 3,700 second-feet); minimum stage, −0.04 foot March 19–20 (discharge, 36 second-feet).

1915–1918: Maximum stage occurred probably on November 1, 1917 (discharge, estimated by comparison with Fish Creek, 5,500 second-feet); minimum discharge, 36 second-feet, March 19–20, 1919.

ICE.—Stage-discharge relation not affected by ice.

ACCURACY.—Stage-discharge relation permanent. Rating curve, determined by five discharge measurements and point of zero flow, is fairly well defined below 2,000 second-feet. Water-stage recorder operated satisfactorily except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging discharges obtained by applying to rating table mean gage heights for regular intervals of day. Results good except for periods of break in record, for which they are fair.

Swan Lake, whose area is about 350 acres, is 1½ miles from tidewater, at an elevation of 225 feet.

Discharge measurements of Swan Lake outlet at Carroll Inlet during 1919.

[Made by G. H. Canfield.]

Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*
Mar. 2	0.23	61
Aug. 30	.95	201

Daily discharge, in second-feet, of Swan Lake outlet at Carroll Inlet for 1919.

Day.	Jan.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Nov.	Dec.
1	176	....	2,240	505	390	390	294	181	....	150
2	170	....	1,540	390	477	374	282	156	....	132
3	188	....	1,020	328	684	397	277	139	....	118
4	720	....	770	306	711	621	274	124	....	107
5	875	....	711	309	577	730	274	118	....	98
6	711	....	577	358	473	621	309	120	....	90
7	1,500	....	445	437	437	533	306	118	....	84
8	1,610	55	358	537	441	465	274	112	103	79
9	1,540	53	303	553	321	441	265	107	126	74
10	1,050	54	280	473	577	418	262	111	114	70
11	745	54	277	465	573	418	257	118	103	66
12	517	54	271	465	505	429	229	143	94	63
13	418	52	251	441	461	473	218	254	143	60
14	384	50	235	608	449	545	254	257	248	59
15	343	50	213	930	433	545	384	221	577	78
16	297	47	193	902	433	481	706	193	760	196
17	254	44	203	720	437	445	590	936	1,420	1,410
18	213	44	274	735	449	411	465	1,750	2,640	3,470
19	176	43	414	1,320	565	384	425	1,500	2,000	2,400
20	141	43	425	1,290	848	364	1,110	1,020	1,470	1,260
21	137	92	400	875	848	358	960	735	1,290	745
22	143	107	343	621	745	340	621	795	875	698
23	141	103	343	497	795	321	425	....	630	1,020
24	135	87	374	726	735	321	321	....	497	1,020
25	132	78	433	1,170	594	343	411	....	374	1,230
26	128	72	848	902	537	337	218	....	297	1,320
27	....	68	1,140	693	521	334	193	....	257	1,170
28	....	111	902	608	473	340	181	....	226	1,020
29	....	210	730	509	457	343	174	....	196	698
30	....	1,260	630	437	425	328	193	....	170	....
31	....	1,890	....	397	....	303	198	....	....	....

NOTE.—Discharge for following periods estimated, because of unsatisfactory operation of water-stage recorder, by comparison with records for Fish Creek: Jan. 14–19, as shown in table; Jan. 27–31, 140 second-feet. From maximum and minimum stages indicated by recorder and by comparison with record for other stations as follows: Feb. 1–28, 120 second-feet; Mar. 1–7, 60 second-feet; Sept. 23–30, 350 second-feet; Oct. 1–31, 340 second-feet; Nov. 1–7, 200 second-feet. Discharge, Dec. 30–31, estimated at 400 second-feet by comparison with record for Fish Creek.

Monthly discharge of Swan Lake outlet at Carroll Inlet for 1919.

Month.	Discharge in second-feet.			Run-off (in acre-feet).
	Maximum.	Minimum.	Mean.	
January	1,610	....	437	26,900
February	....	....	120	6,660
March	1,890	43	166	10,200
April	2,240	193	571	34,000
May	1,320	306	629	38,700
June	848	321	546	32,500
July	730	303	424	26,100
August	1,110	174	366	22,500
September	1,750	....	400	23,800
October	....	....	340	20,900
November	2,640	94	534	31,800
December	3,470	59	638	39,200
The year	3,470	43	433	313,000

ORCHARD LAKE OUTLET AT SHRIMP BAY, REVILLAGIGEDO ISLAND.

LOCATION.—In latitude 55° 50′ N., longitude 131° 27′ W., at outlet of Orchard Lake, one-third mile from tidewater at head of Shrimp Bay, an arm of Behm Canal, 46 miles by water from Ketchikan.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—May 28, 1915, to December 31, 1919.

GAGE.—Stevens water-stage recorder on right bank 300 feet below Orchard Lake and 100 feet above site of timber-crib dam, which was built in 1914 for proposed pulp mill and washed out by high water August 10, 1915. Datum of gage lowered 2 feet September 15, 1915. Gage heights May 29 to August 10 referred to first datum; August 11, 1915, to August 17, 1916, to second datum. Datum of gage lowered 1 foot August 17, 1916. Gage heights August 18 to December 31, 1916, referred to this datum. Gage washed out probably during high water on November 1, 1917. New gage installed on April 28, 1918, at old site at the datum of August 17, 1916.

DISCHARGE MEASUREMENTS.—At medium and high stages made from cable 5 feet upstream from gage; at low stages by wading one-fourth mile below gage.

CHANNEL AND CONTROL.—From Orchard Lake, at elevation 134 feet above high tide, the stream descends in a series of rapids for 1,000 feet through a narrow gorge, then divides into two channels and enters the bay in two cascades of 100-foot vertical fall. Opposite the gage the water is deep and the current sluggish. At the site of the old dam bedrock is exposed, but for 30 feet upstream the channel is filled in with loose rock and brush placed during construction of dam. This material forms a riffle which acts as a control for water surface at gage at low and medium stages and is scoured down when ice goes out of lake; the rock outcrop at site of old dam acts as a control at high stages and is permanent.

EXTREMES OF DISCHARGE.—Maximum stage during year from water-stage recorder, 9.65 feet at 12 p. m. December 18 (discharge, 6,660 second-feet); minimum stage recorded, −0.02 foot March 19 (discharge, 35 second-feet).

1915–1919: Maximum stage occurred, probably, on November 1, 1917 (discharge estimated by multiplying maximum discharge at Fish Creek on that date by 1.55, which is the ratio between the maximum discharges of Orchard Lake outlet and Fish Creek on October 16 and 15, 1915, 7,100 second-feet); minimum discharge, estimated, 20 second-feet February 11, 1916.

ICE.—Stage-discharge relation not affected by ice.

ACCURACY.—Stage-discharge relation changes occasionally during high water. Rating curve, determined by five discharge measurements made since new gage was installed, point of zero flow, and form of upper portion of old rating curve, is well defined below 4,000 second-feet. Water-stage recorder operating satisfactory except for periods indicated in footnote to daily-discharge table Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of day. Records good, except for period of break in record, for which they are fair.

The highest mountains on this drainage basin are only 3,500 feet above sea level and are covered to an elevation of 2,500 feet by a heavy stand of timber and a thick undergrowth of brush, ferns, alders, and devil's club. The topography is not so rugged as that of the area surrounding Shelockum Lake, and the proportion of vegetation, soil cover, and lake area is greater, so that more water is stored and the flow in the Orchard Lake drainage is better sustained.

Discharge measurements of Orchard Lake outlet at Shrimp Bay during 1919.

[Made by G. H. Canfield.]

Date.		Gage height.	Discharge.
		Feet.	*Sec.-ft.*
Mar. 4		0.21	59
Sept. 3		1.17	193

Daily discharge, in second-feet, of Orchard Lake outlet at Shrimp Bay for 1919.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Dec.
1	172	99	77	2,530	660	620	600	374	323	....
2	166	92	72	1,550	522	720	560	368	242	....
3	232	85	63	1,080	433	1,000	580	353	203	....
4	1,070	84	57	880	407	1,060	762	347	166	....
5	1,310	81	55	762	426	880	980	359	148	....
6	955	75	54	660	533	762	830	362	145	....
7	2 090	75	53	514	720	720	740	338	140	....
8	2,000	75	51	400	905	720	640	305	131	66
9	1,980	94	51	338	855	785	596	323	125	64
10	1,310	148	52	326	700	855	572	320	122	64
11	980	203	51	338	660	830	580	291	130	64
12	660	203	48	329	660	785	588	272	145	65
13	522	176	46	308	616	740	628	254	214	65
14	440	159	44	286	855	700	628	257	225	66
15	353	140	42	254	1,280	700	628	317	201	66
16	272	148	41	235	1,130	700	604	572	174	90
17	216	203	40	280	930	700	600	529	951	1,140
18	188	230	37	485	1,030	720	568	474	1,860	5,790
19	164	244	35	660	1,890	830	532	492	1,820	3,040
20	138	240	37	612	1,680	1,060	514	1,250	1,160	1,450
21	125	205	44	522	1,080	1,030	511	1,110	880	680
22	125	162	61	426	762	905	474	710	980	740
23	128	140	83	467	680	980	443	503	680	1,310
24	124	124	97	580	1,430	880	443	368	....	1,490
25	119	113	97	700	1,430	700	471	286	....	1,680
26	115	105	94	1,030	1,030	640	453	235	....	1,960
27	108	96	87	1,490	880	640	450	207	....	1,160
28	106	84	110	1,160	785	640	467	194	....	1,080
29	106	....	398	930	700	680	460	212	....	660
30	110	....	1,910	762	660	660	420	344	....	433
31	105	....	2,410	....	620	....	384	400	....	305

NOTE.—Daily discharge for following periods estimated, because of unsatisfactory operation of water-stage recorder: Feb. 22 to Mar. 3, by comparison with hydrographs for other stations; Apr. 8 and 9, by interpolation; May 27 to June 16, from gage-height graph drawn through maximum and minimum stages shown by recorder and by comparison with record for Swann Lake outlet. Discharge for following periods estimated from maximum and minimum stages indicated by recorder and by comparison with records for other stations: Sept. 24–30, 320 second-feet; Oct. 1–31, 500 second-feet; Nov. 1–12, 200 second-feet; Nov. 13–30, 850 second-feet; and Dec. 1–7, 100 second-feet.

Monthly discharge of Orchard Lake outlet at Shrimp Bay for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	2,090	105	532	32,700
February	244	75	139	7,720
March	2,410	35	206	12,700
April	2,530	235	696	41,400
May	1 890	407	869	53,400
June	1,060	620	788	46,900
July	980	384	571	35,100
August	1,250	194	411	25,300
September	1,860	122	447	26,600
October	....	....	500	30,700
November	....	....	590	35,100
December	5,790	....	791	48,600
The year	5,790	35	548	396,000

SHELOCKUM LAKE OUTLET AT BAILEY BAY.

Location.—In latitude 56° 00′ N., longitude 131° 36′ W., on mainland near outlet of Shelockum Lake, three-fourths mile by Forest Service trail from tidewater at north end of Bailey Bay and 52 miles by water north of Ketchikan.

Drainage area.—18 square miles (measured on sheets Nos. 5 and 8 of the Alaska Boundary Tribunal, edition of 1895).

Records available.—June 1, 1915, to October 31, 1919. (Gage-height graph, December 8–31, 1919, could not be removed from recorder, because of ice in bay, in time for inclusion in this bulletin.)

Gage.—Stevens continuous water-stage recorder on right shore of lake, 250 feet above outlet. Gage house was pushed off the well by a snowslide January 4, 1917. Gage not put into operation again until May 23, 1917.

Discharge measurements.—Made from cable across outlet of lake, 200 feet below gage and 50 feet upstream from crest of falls.

Channel and control.—Opposite the gage the lake is 600 feet wide; at the outlet bedrock is exposed and the water makes a nearly perpendicular fall of 150 feet. This fall forms an excellent and permanent control for the gage. At extremely high stages the lake has another outlet about 200 feet to left of main outlet. Point of zero flow is at gage height 0.6 foot.

Extremes of discharge.—Maximum stage recorded during year occurred, probably, on December 13; minimum discharge (estimated from hydrograph for Fish Creek to have occurred March 21), 8 second-feet.

1915–1919: Maximum stage, 6.84 feet at 8 a. m. November 1, 1917 (discharge, 2,780 second-feet); minimum discharge, estimated from climatic records, 2.5 second-feet, January 31, 1917.

Ice.—Stage-discharge relation not affected by ice.

Accuracy.—Stage-discharge relation permanent. Rating curve well defined. Operation of water-stage recorder satisfactory except for periods of break in record shown in the footnote to daily-discharge table. Daily discharge ascertained by applying to the rating table mean daily gage height determined by inspection of gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of day. Records excellent, except for periods of break in record, for which they are fair.

Shelockum Lake, at an elevation of 344 feet, covers only 350 acres. The drainage basin above the lake is rough, precipitous, and covered with little soil or vegetation. There are no glaciers or ice fields at the source of the tributary streams. Therefore, because of little natural storage, the run-off after a heavy rainfall is rapid and not well sustained, and during a dry summer or winter the flow becomes very low. The large amount of snow that accumulates on the drainage basin during the winter maintains a good flow in May and June.

The following discharge measurement was made by G. H. Canfield:

March 4, 1919: Gage height, 1.14 feet; discharge, 15 second-feet.

Daily discharge, in second-feet, of Shelockum Lake outlet at Bailey Bay for 1919.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept
1	51	....	....	....	220	220	250	172	95
2	73	....	....	....	190	252	241	168	71
3	115	....	....	....	164	350	245	162	64
4	350	....	18	....	150	392	363	160	55
5	299	....	17	....	160	336	490	164	50
6	620	....	18	....	210	311	407	164	48
7	730	....	19	....	237	292	336	156	45
8	438	....	19	....	363	292	292	145	42
9	....	....	20	....	350	306	277	137	39
10	....	....	21	....	275	304	275	132	40
11	....	....	20	....	241	301	270	119	48
12	....	....	19	....	263	299	287	110	65
13	....	....	17	....	252	294	363	100	156
14	....	....	17	....	311	292	392	123	176
15	....	....	16	....	490	287	363	184	141
16	....	....	....	....	392	282	311	392	110
17	....	....	....	....	311	280	287	455	453
18	....	....	....	....	299	287	275	316	1,180
19	....	....	....	....	422	336	252	287	860
20	45	....	....	....	378	508	237	660	472
21	43	....	....	....	311	508	226	455	407
22	45	....	....	....	287	407	216	275	525
23	45	....	....	....	263	407	204	180	311
24	45	....	....	....	378	369	206	132	220
25	43	....	....	....	363	306	216	102	....
26	41	....	....	542	311	275	210	84	....
27	41	....	....	640	287	277	210	73	....
28	41	....	....	472	263	275	210	68	....
29	48	....	....	336	252	273	208	75	....
30	57	....	....	263	241	259	196	100	....
31	48	....	....	....	230	....	180	140	....

NOTE.—Discharge for following periods estimated, because of unsatisfactory operation of water-stage recorder, from maximum and minimum stages indicated by recorder and by comparison with hydrographs for other stations: Jan. 9–19, 115 second-feet; Feb 1–28, 45 second-feet; Mar. 1–3, 20 second-feet; Mar. 16–31, 75 second-feet; Apr. 1–25, 220 second-feet; Aug. 28 to Sept. 1, daily discharge as shown in table; Sept. 25–30, 110 second-feet; and Oct. 1–31, 200 second-feet.

Monthly discharge of Shelockum Lake outlet at Bailey Bay for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	730	41	145	8,920
February	....	....	45	2,500
March	....	....	47.8	2,940
April	....	....	258	15,400
May	490	150	288	17,700
June	508	220	319	19,000
July	490	180	274	16,800
August	660	68	193	11,900
September	1,180	39	211	12,600
October	....	....	200	12,300
The period	....	....	....	120,000

KARTA RIVER AT KARTA BAY, PRINCE OF WALES ISLAND.

LOCATION.—In latitude 55° 34′ N., longitude 132° 37′ W., at head of Karta Bay, an arm of Kasaan Bay, on east coast of Prince of Wales Island, 42 miles by water across Clarence Strait from Ketchikan.

DRAINAGE AREA.—49.5 square miles (U. S. Forest Service reconnaissance map of Prince of Wales Island, 1914).

RECORDS AVAILABLE.—July 1, 1915, to December 31, 1919.

GAGE.—Stevens continuous water-stage recorder on left bank, half a mile above tidewater, at head of Karta Bay and 1¼ miles below outlet of Little Salmon Lake. Two per cent of total drainage of Karta River enters between outlet of lake and gage.

DISCHARGE MEASUREMENTS.—At medium and high stages made from cable across river 50 feet upstream from gage; at low stages by wading at cable section.

CHANNEL AND CONTROL.—From Little Salmon Lake, 1½ miles from tidewater, the river descends 105 feet in a series of rapids in a wide, shallow channel, the banks of which are low but do not overflow. The bed is of coarse gravel and boulders; rock crops out only at outlet of lake. Gage and cable are at a pool of still water formed by a riffle of coarse gravel that makes a well-defined and permanent control.

EXTREMES OF DISCHARGE.—Maximum stage during the year from water-stage recorder, 4.75 feet estimated to have occurred December 18 (discharge, from extension of rating curve, 3,900 second-feet); minimum stage, 0.85 foot, March 19 (discharge, 54 second-feet).

1915–1919: Maximum stage, 5.5 feet November 1, 1917 (discharge, 5,070 second-feet); minimum flow, 21 second-feet, February 11, 1916.

ACCURACY.—Stage-discharge relation permanent. Rating curve well defined between 80 and 1,500 second-feet; extended below 80 second-feet to the point of zero flow and above 1,500 second-feet by estimation. Operation of water-stage recorder satisfactory except for periods indicated by breaks in record as shown in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying gage heights for regular intervals to rating table. Records excellent except for periods of breaks in record, for period affected by ice, and for discharge above 1,500 second-feet, for which they are fair.

The combined area of Little Salmon Lake at elevation 105 feet and Salmon Lake at elevation 110 feet is 1,600 acres. The slopes along the right shore of lakes and at head of Salmon Lake are gentle, and the area included by the 250-foot contour above lake outlet is 5,500 acres. The drainage area to elevation 2,000 feet is heavily covered with timber and dense undergrowth of ferns, brush, and alders. The upper parts of the mountains are covered with thin soil and brush. Only a few peaks at an elevation of 3,500 feet are bare. This large lake and flat area and thick vegetal cover afford considerable natural storage, which, after heavy precipitation, maintains a good run-off. The snow usually melts by the end of June, and the run-off becomes very low during a dry, hot summer.

The Forest Service in the summer of 1916 constructed a pack trail from tidewater to outlet of Little Salmon Lake.

The following discharge measurement was made by G. H. Canfield:

March 6, 1919: Gage height, 0.98 foot; discharge, 85 second-feet.

Daily discharge, in second-feet, of Karta River at Karta Bay for 1919.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	176	......	1,700	565	402	238	115	88	160	302	......
2	......	156	......	1,410	474	428	229	109	88	142	290	......
3	......	145	......	1,090	402	441	233	103	83	152	238	......
4	......	142	......	907	356	448	320	97	76	197	215	......
5	......	135	......	880	356	448	350	94	71	220	172	......
6	......	128	83	756	402	422	338	91	69	248	152	......
7	......	121	83	610	480	389	308	88	64	448	128	......
8	......	156	83	522	572	338	314	88	58	515	125	......
9	......	206	83	480	565	344	314	88	58	448	145	......
10	......	248	86	448	558	395	308	86	56	550	152	......
11	......	259	83	434	773	376	296	83	56	572	145	......
12	......	233	81	454	714	350	308	78	56	529	135	......
13	......	233	78	434	633	338	314	78	60	448	......	......
14	633	233	74	415	799	332	338	76	69	363	......	......
15	501	215	71	382	925	332	338	78	69	290	......	......
16	395	269	66	344	943	320	314	145	71	248	......	......
17	308	460	60	344	826	302	285	164	164	215	......	......
18	264	508	58	422	782	296	269	176	1,050	210	......	......
19	228	522	54	633	1,170	338	243	238	1,420	382	......	......
20	196	460	56	714	1,330	382	233	415	1,070	515	......	1,270
21	180	396	91	673	1,080	389	215	320	808	529	......	790
22	192	308	138	580	782	396	206	308	853	515	......	756
23	206	264	168	529	633	382	197	238	681	434	......	1,100
24	197	215	168	558	826	363	180	192	515	350	......	1,060
25	188	192	160	602	1,000	338	172	156	428	290	......	1,470
26	176	164	145	898	826	344	160	132	350	238	......	2,240
27	184	......	152	1,040	665	326	149	112	290	215	......	1,760
28	197	......	184	925	550	302	142	100	238	238	......	1,230
29	196	......	338	835	494	280	135	94	206	215	......	808
30	220	......	961	697	467	254	128	91	180	215	......	580
31	107	......	1,230	......	428	......	121	97	......	302	......	454

NOTE.—Discharge estimated for following periods, because of unsatisfactory operation of water-stage recorder, from maximum and minimum stages indicated by recorder and by comparison with hydrographs for other stations: Jan. 1–13, 1,300 second-feet; Feb. 27–28, 135 second-feet; Mar. 1–5, 100 second-feet; Nov. 13–30, 800 second-feet; Dec. 1–14, 90 second-feet; and Dec. 15–19, 1,500 second-feet.

Monthly discharge of Karta River at Karta Bay for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	....	176	695	42,700
February	522	121	243	13,500
March	1,230	54	172	10,600
April	1,700	344	691	41,100
May	1,330	356	690	42,400
June	448	254	360	21,400
July	350	121	248	15,200
August	415	76	140	8,610
September	1,420	56	312	18,600
October	572	142	335	20,600
November	....	....	553	32,900
December	....	....	719	44,200
The year	....	54	431	312,000

CASCADE CREEK AT THOMAS BAY, NEAR PETERSBURG.

LOCATION.—One-fourth mile above tidewater on each shore of south arm of Thomas Bay; 22 miles by water from Petersburg. One small tributary enters the river from the left half a mile above gage and 2 miles below lake outlet.

DRAINAGE AREA.—21.4 square miles (measured on the United States Geological Survey geologic reconnaissance map of the Wrangell mining district, edition of 1907).

RECORDS AVAILABLE.—October 27, 1917, to December 31, 1919.

GAGE.—Stevens water-stage recorder on left bank, one-fourth mile from tidewater; reached by trail which leaves beach back of old cabin at mouth of creek.

DISCHARGE MEASUREMENTS.—At medium and high stages, made from log footbridge across stream one-fourth mile upstream from gage; at low stages, made by wading.

CHANNEL AND CONTROL.—From the outlet of a lake at an elevation of 1,200 feet above sea level and 3 miles from tidewater the river descends in a continuous series of rapids and falls through a narrow, deep canyon. Gage is in a protected eddy above a natural rock weir, which forms a well-defined and permanent control. The bed of river under the footbridge is rough and the current swift and irregular, but this section is the only place on the whole river where even at low and medium stages there are no boils and eddies.

EXTREMES OF DISCHARGE.—Maximum stage during year from water-stage recorder, 7.0 feet at 10 p. m. September 21 (discharge, from extension of rating curve, 1,570 second-feet); minimum discharge, 20 second-feet, estimated from climatic data and record of flow of Sweetheart Falls Creek.

1917–1919: Maximum stage, 7.65 feet at 11 p. m. November 18, 1917 (discharge computed from extension of rating curve, 1,980 second-feet); minimum stage 0.80 foot about April 6, 1918 (discharge, 17 second-feet).

ICE.—Stage-discharge relation affected by ice for short periods.

ACCURACY.—Stage-discharge relation permanent. Rating curve well defined below 1,200 second-feet. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging discharge for equal intervals of day. Records good except for periods when recorder did not operate satisfactorily, for which they are fair.

The first site on this stream for a storage reservior is at a small lake 3 miles from tidewater, at an elevation of 1,200 feet above sea level. The drainage area above the gaging station is 21 square miles and above the lake outlet 17 square miles. Flow during summer is augmented by melting ice from glaciers on upper portion of drainage area.

No discharge measurements were made at this station during the year.

Daily discharge, in second-feet, of Cascade Creek at Thomas Bay for 1919.

Day.	Feb.	Mar.	Apr.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1			75	145	380	518	250	146	86	57
2			60	180	380	485	200	150	76	54
3			55	192	395	470	167	532	68	51
4			48	183	485	470	153	890	63	49
5			47	175	518	518	153	890	57	46
6			44	167	535	500	150	1,110	54	44
7			40	183	518	440	160	1,040	50	42
8			38	200	470	485	183	658	48	40
9			40	240	470	570	200	410	48	
10			39	280	518	518	410	342	46	
11			42	280	485	470	605	330	44	
12				292	500	455	518	270	42	
13				292	535	455	570	200	54	
14	25			270	570	710	588	160	59	
15	25			260	622	850	485	134	88	
16	25			280	535	978	440	119	87	
17	26			318	455	790	672	111	122	
18	26			318	380	810	850	109	342	
19	26			380	355	910	692	146	280	
20	26			605	380	1,320	552	302	270	
21	24			570	395	890	976	640	220	
22	25			500	395	640	1,140	425	153	
23	24			455	395	455	830	260	131	
24	24			440	395	368	850	183	112	
25	23			410	425	342	1,020	146	96	
26	23			440	425	330	675	126	83	
27	23			425	470	342	440	121	74	
28	22			395	552	395	292	124	69	
29		27		395	622	440	220	107	65	
30		70		380	640	440	175	94	61	
31		82			570	342		92		

NOTE.—Discharge for following periods estimated, because of ice effect or unsatisfactory operation of water-stage recorder, from hydrograph drawn by comparison with that for Sweetheart Falls Creek through maximum and minimum stages indicated by recorder: Jan. 1–13, 161 second-feet; Feb. 1–13, 30 second-feet; Feb. 26–28, daily discharge; Mar. 1–28, 24 second-feet; Apr. 12–30, 90 second-feet; May 1–31, 155 second-feet; June 1–2, daily discharge; Dec. 9–15, 38 second-feet; and Dec. 16–31, 100 second-feet.

Monthly discharge of Cascade Creek at Thomas Bay for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January			161	9,900
February		22	27.0	1,500
March	82		27.4	1,680
April		38	74.6	4,440
May			155	9,530
June	605	145	322	19,200
July	640	355	476	29,300
August	1,320	330	571	35,100
September	1,140	150	487	29,000
October	1,110	92	334	20,500
November	342	42	102	6,070
December			72.5	4,460
The year	1,320	22	236	171,000

GREEN LAKE OUTLET AT SILVER BAY, NEAR SITKA.

LOCATION.—In latitude 56° 59′ N., longitude 135° 5′ W., at outlet of Green Lake, head of Silver Bay, 10½ miles by water south of Sitka.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—August 22, 1915, to December 31, 1919.

GAGE.—Stevens water-stage recorder on right bank, at outlet of lake, reached by trail which leaves the beach one-fourth mile north of mouth of stream, ascends a 600-foot ridge, and then drops down to the outlet of the lake. Gage datum lowered 1 foot December 27, 1916.

DISCHARGE MEASUREMENTS.—Made from cable across outlet 30 feet below gage.

CHANNEL AND CONTROL.—From Green Lake, 240 feet above sea level and 1,800 feet from tidewater, the stream descends in a series of falls and rapids through a narrow canyon whose exposed rock walls rise vertically more than 100 feet.

EXTREMES OF DISCHARGE.—Maximum stage during year, 12.4 feet, probably on October 6, estimated from vertical line traced by recording pencil while clock of recorder did not run (discharge, estimated from extension of rating curve, 3,000 second-feet); minimum stage recorded, −0.05 foot March 27–29 (discharge, 10 second-feet).

1915–1919: Maximum stage recorded, 13.0 feet, September 26, 1918 (discharge, estimated from extension of rating curve, 3,300 second-feet); minimum stage recorded, −0.05 foot March 27–29, 1919 (discharge, 10 second-feet).

ICE.—Ice forms on lake and at gage, but because of current and flow of relatively warm weather from the lake the control remains open.

ACCURACY.—Stage-discharge relation permanent. Rating curve well defined between 10 and 1,300 second-feet. Operation of water-stage recorder satisfactory except for periods indicated by breaks in record, as shown in the footnote to the daily-discharge table. Daily discharge ascertained by applying to the rating table mean daily gage height, determined by inspecting gage-height graph, or, for days of considerable fluctation, by averaging results obtained by applying to rating table gage heights for regular intervals of day. Records good, except those for periods when gage was not operating satisfactorily, which are fair.

In the fall and winter the flow is low because there is little ground storage, and on most of the drainage area the precipitation is in the form of snow. This accumulated snow produces a large run-off during the spring, and the melting ice from the glacier and the ice-capped mountains augments the run-off from precipitation during the summer. The area of Green Lake is estimated to be about 175 acres. [3]

The discharge measurements were made at the station during the year.

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[3] Supersedes figure published in U. S. Geol. Survey Bulls. 662, 692, and 712.

Daily discharge, in second-feet, of Green Lake outlet at Silver Bay for 1919.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Oct.	Nov.	Dec.
1	70	44	16	147	138	172	303	......	......	......	66
2	142	43	16	164	114	212	354	......	......	......	60
3	188	40	15	140	100	233	461	......	......	......	60
4	144	40	......	132	97	233	620	......	......	......	60
5	173	38	......	130	102	212	673	......	......	......	57
6	713	38	......	126	124	206	557	......	......	......	62
7	1,580	38	......	100	206	200	547	......	......	......	69
8	820	34	......	85	286	194	547	......	......	......	59
9	568	36	......	79	294	240	547	......	......	......	46
10	557	42	......	76	226	286	547	......	......	......	38
11	480	48	......	73	337	380	557	......	......	......	37
12	226	43	......	73	182	328	599	......	......	......	38
13	177	38	......	76	247	354	588	......	......	......	40
14	138	38	......	76	312	312	630	......	......	......	43
15	122	33	......	70	470	286	518	461	......	......	44
16	107	32	......	67	442	312	397	433	......	......	......
17	92	37	......	66	490	362	346	415	......	......	......
18	80	42	......	85	303	371	337	371	......	......	......
19	73	58	......	134	397	490	362	433	182	......	......
20	67	59	12	156	528	652	388	641	338	......	......
21	66	48	18	142	406	547	406	489	820	......	......
22	67	40	18	116	262	588	288	371	397	......	......
23	67	36	16	107	212	620	388	303	219	......	......
24	61	30	14	126	226	508	380	......	172	......	......
25	59	27	12	154	303	499	354	......	142	......	......
26	55	24	11	240	240	452	362	......	126	......	......
27	55	18	10	294	194	415	452	......	134	......	......
28	53	18	10	219	168	415	652	......	......	......	......
29	60	......	10	168	162	388	706	......	......	......	......
30	57	......	12	155	164	346	652	......	......	79	......
31	51	......	30	......	166	......	518	......	......	......	......

NOTE.—Discharge for following periods extimated, because of unsatisfactory operation of water-stage recorder, by comparison with hydrographs for other stations: Mar. 3, 15 second-feet and Mar. 4–19, 15 second-feet; from maximum and minimum stages indicated by recorder and by comparison with record of flow for Sweetheart Falls Creek: Aug. 1–14, 500 second-feet; Aug. 24–31, 385 second-feet; Sept. 1–30, 500 second-feet; and Oct. 1–18, 500 second-feet; from maximum and minimum stages indicated by recorder and by comparison with climatic data for Juneau and hydrographs of other stations: Oct. 28–31, 155 second-feet; Nov. 1–29, 185 second-feet; and Dec. 16–31, 200 second-feet.

Monthly discharge of Green Lake outlet at Silver Bay for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	1,580	51	231	14,200
February	59	18	37.9	2,100
March	30	10	14.8	910
April	294	66	126	7,500
May	528	97	255	15,700
June	652	172	358	21,300
July	706	303	488	30,000
August	......	......	452	27,800
September	......	......	500	29,800
October	......	......	392	24,100
November	......	......	181	10,800
December	......	37	128	7,870
The year	1,580	10	265	192,000

BARANOF LAKE OUTLET AT BARANOF, BARANOF ISLAND.

LOCATION.—In latitude 57° 5′ N., longitude 134° 54′ W., at townsite of Baranof, at head of Warm Spring Bay, east coast of Baranof Island, 18 miles east of Sitka across island but 96 miles from Sitka by water through Peril Strait.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—June 28, 1915, to December 31, 1919.

GAGE.—Stevens water-stage recorder on right bank 700 feet below Baranof Lake and 800 feet above tidewater at head of Warm Spring Bay.

DISCHARGE MEASUREMENTS.—At medium and high stages, from cable across stream 100 feet below lake and 600 feet above gage; at low stages, by wading 100 feet below cable.

CHANNEL AND CONTROL.—From Baranof Lake, at elevation 130 feet above sea level and 1,500 feet from tidewater, the stream descends in a series of rapids and small falls and enters the bay in a cascade of about 100 feet concentrated fall. The bed is of glacial drift, boulders, and rock outcrop. The gage is in an eddy 50 feet downstream from the foot of a small fall and 100 feet upstream from a riffle which forms a well-defined control.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year, 4.78 feet at 3 p. m., October 6 (discharge, computed from an extension of rating curve, 2,610 second-feet); minimum flow, estimated by comparison with record of flow for Green Lake outlet, 20 second-feet, March 27–29.

1915–1919: Maximum stage recorded during period, 5.3 feet August 10, 1915 (discharge, computed from extension of rating curve, 3,350 second-feet); minimum flow, estimated, 20 second-feet, March 27–29, 1919.

ICE.—Because of the swift current and flow of relatively warm water from the lake the stream remains open.

DIVERSIONS.—The flume to Olsen's sawmill diverts from the stream 200 feet below gage only sufficient water to operate a 25-horsepower Pelton water wheel.

ACCURACY.—Stage-discharge relation permanent, not affected by ice. Rating curve well defined below 2,000 second-feet. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging discharge for equal intervals of day. Records good except for periods when recorder did not operate satisfactorily and for periods when water was frozen in well, for which they are roughly approximate.

The drainage area is rough and precipitous, and the vegetable and soil cover is thin, even on the foothills of the mountains. The run-off is rapid, and the ground storage is small. During a hot, dry period, however, the flow is greatly augmented by melting ice from several small glaciers and ice-capped mountains.

No discharge measurements were made at this station during the year.

Daily discharge, in second-feet, of Baranof Lake outlet at Baranof for 1919.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1		255	396	640		392	279	171
2		222	436	640		321	435	141
3		197	450	668		285	1,540	124
4		187	450	890		261	2,000	110
5		191	436	1,100		252	1,940	94
6		225	456	1,010		252	2,320	83
7		297	468	930		264	1,540	84
8		380	456	820		300	855	80
9		420	500	788		424	545	
10		460	615	820		615	476	
11		788	640	890		590	392	
12		695	640	1,050		640	345	
13		545	668	1,100		1,940	285	
14		725	668	1,140		1,650	255	
15		970	615	930		1,010	230	
16		820	590	725		755	230	
17	119	615	615	640		890	230	
18	129	590	615	590		1,330	270	
19	173	695	725	615		1,050	291	
20	235	788	930	668		788	500	
21	252	640	855	725		1,540	545	
22	235	522	855			1,430	396	
23	242	464	890			855	306	
24	261	590	855			1,010	255	
25	282	615	820			1,380	218	
26	321	484	820			820	193	
27	366	404	788			545	191	
28	348	356	788			420	189	
29	312	342	755		590	352	183	
30	291	348	668		590	321	203	
31		366			500		193	

NOTE.—Discharge for following periods estimated, because of unsatisfactory operation of gage, by comparison with record for Green Lake outlet: Jan. 1-31, 280 second-feet; Feb. 1-28, 60 second-feet; Mar. 1-31, 30 second-feet; Apr. 1-16, 170 second-feet. Discharge for following periods estimated by comparison with record for Sweetheart Falls Creek: June 3-4, 450 second-feet; July 22-31, 825 second-feet; Aug. 1-28, 770 second-feet. Following periods estimated from maximum and minimum stages shown by gage and by comparison with records for other stations: Nov. 9-30, 210 second-feet; Dec. 1-15, 55 second-feet; Dec. 16-31, 215 second-feet.

Monthly discharge of Baranof Lake outlet at Baranof for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January			280	17,200
February			60	3,330
March			30	1,840
April			210	12,500
May	970	187	490	30,100
June	930	396	649	38,600
July			827	50,800
August			750	46,100
September	1,940	252	756	45,000
October	2,320	183	575	35,400
November			184	10,900
December			138	8,480
The year			415	300,000

SWEETHEART FALLS CREEK NEAR SNETTISHAM.

Location.—In latitude 57° 56½′ N., longitude 133° 41′ W., on east shore 1 mile from head of south arm of Port Snettisham, 3 miles south of mouth of Whiting River, 7 miles by water from Snettisham, and 42 miles by water from Juneau. No large tributaries enter river between gaging station and outlet of large lake, 2½ miles upstream.

Drainage area.—27 square miles (measured on United States Geological Survey topographic map of the Juneau gold belt, edition of 1905).

Records available.—July 31, 1915, to March 31, 1917; May 21, 1918, to December 31, 1919.

Gage.—Stevens water-stage recorder on right bank, 300 feet upstream from tidewater on east shore of Port Snettisham. Gage washed out in November, 1917, and record from April 20, 1917, lost with gage. New Stevens water-stage recorder installed May 21, 1918, at same datum and at approximate location of old gage.

Discharge measurements.—At medium and high stages, made from cable across river one-fourth mile upstream from gage; at low stages, made by wading in channel at mouth of creek exposed at low tide.

Channel and control.—From the outlet of the lake at an elevation of 520 feet above sea level and 2½ miles from tidewater the water descends in a series of rapids and falls through a narrow, deep canyon. Gage is in a pool at foot of two falls, each 25 feet high, which are known as Sweetheart Falls; outlet of pool is a natural rock weir, which forms a well-defined and permanent control for gage.

Extremes of discharge.—Maximum stage during year from water-stage recorder, 6.0 feet at 10 p. m. October 6 (discharge computed from extension of rating curve, 2,260 second-feet); minimum stage, 0.15 foot 12 a. m. March 29 (discharge, 28 second-feet).

1915–1919 (except for period of no record): Maximum stage recorded, 7.15 feet at midnight, September 26, 1918 (discharge, computed from an extension of the rating curve, 2,880 second-feet); minimum flow, estimated from discharge measurement and climatic data, 15 second-feet February 11, 1916.

Ice.—Stage-discharge relation affected by ice only for short periods during extremely cold weather.

Accuracy.—Stage-discharge relation permanent. Rating curve well defined between 40 and 1,300 second-feet; extended beyond these limits by estimation. Operation of water-stage recorder satisfactory except for periods shown in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table gage heights for regular intervals of day. Records excellent except for periods of ice effect or break in record and for discharge above 1,300 second-feet, for which they are fair.

In the fall and winter the run-off is small because the precipitation is in the form of snow, and because of the small amount of ground storage; during a hot, dry period the low run-off from the ground and lake stage is augmented by melting ice from one glacier.

The following discharge measurement was made by G. H. Canfield:

February 16, 1919: Gage height, 0.35 foot; discharge, 48 second-feet.

Daily discharge, in second-feet, of Sweetheart Falls Creek near Snettisham for 1919.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	102	73	42	82	240	324	565	645	545	264	121	76
2	141	67	41	98	199	351	545	565	435	216	113	70
3	176	62	41	90	176	428	505	525	348	418	102	66
4	169	58	42	90	164	449	525	470	285	1,120	90	62
5	300	55	50	141	159	424	585	525	240	1,280	84	58
6	745	58	60	141	164	382	705	605	216	2,010	79	57
7	845	50	60	119	183	365	865	565	202	2,010	74	54
8	945	49	57	109	240	365	805	565	199	1,350	70	50
9	805	48	47	108	285	393	705	645	196	885	70	44
10	585	48	42	102	294	470	705	665	255	545	67	42
11	505	49	37	95	294	525	645	585	452	386	64	41
12	365	49	34	95	294	585	585	525	488	315	62	40
13	285	47	37	92	300	585	565	488	545	258	60	39
14	225	60	44	92	306	525	645	525	925	210	64	41
15	178	52	39	90	372	488	685	705	905	176	72	52
16	152	48	33	87	463	470	625	705	705	152	85	59
17	131	47	37	85	460	525	545	665	565	146	113	113
18	113	82	38	90	442	545	525	605	685	144	270	435
19	102	64	38	117	488	545	488	665	845	164	488	382
20	93	64	48	125	645	625	505	968	725	231	442	276
21	85	58	60	129	605	725	545	968	705	585	460	196
22	87	53	58	127	488	685	565	745	1,010	565	390	159
23	90	47	48	125	410	645	565	545	1,060	390	285	144
24	90	46	39	131	382	625	545	435	990	285	210	148
25	87	44	34	183	410	605	525	382	1,170	213	150	171
26	74	44	32	300	428	705	505	348	1,170	174	127	300
27	104	44	30	400	393	785	525	324	905	148	113	330
28	88	43	30	365	354	685	605	330	605	141	104	249
29	90	....	29	315	327	625	745	393	428	137	93	188
30	87	....	38	285	315	585	825	585	330	129	84	149
31	79	....	42	....	309	....	745	625	....	125	....	133

NOTE.—Daily discharge for following periods estimated by comparison with hydrograph for Cascade Creek, because stage-discharge relation was affected by ice or because of unsatisfactory operation of water-stage recorder: Jan. 5–8, Feb. 27 to Mar. 5, Apr. 1–7, and Dec. 10–12.

Monthly discharge of Sweetheart Falls Creek near Snettisham for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	945	74	256	15,700
February	82	43	53.9	2,990
March	60	29	42.2	2,590
April	400	82	147	8,750
May	645	159	342	21,000
June	785	324	535	31,800
July	865	488	613	37,700
August	968	324	577	35,500
September	1,170	196	604	35,900
October	2,010	125	489	30,100
November	488	60	154	9,160
December	435	39	136	8,360
The year	2,010	29	331	240,000

CRATER LAKE OUTLET AT SPEEL RIVER, PORT SNETTISHAM.

LOCATION.—At outlet of Crater Lake, 1 mile upstream from edge of tide flats at head of north arm of Port Snettisham, 2 miles by trail from cabins of Speel River project, which are 42 miles by water from Juneau.

DRAINAGE AREA.—11.9 square miles above water-stage recorder at lake outlet, and 13 square miles above staff gage at beach (measured on topographic maps of the Alaska Boundary Tribunal, edition of 1895).

RECORDS AVAILABLE.—January 23, 1913, to December 31, 1919.

GAGE.—Stevens water-stage recorder on left shore of lake 100 feet upstream from outlet. A locally made water-stage recorder having a natural vertical scale and a time scale of 7 inches to 24 hours was used until replaced by Stevens gage June 29, 1916. The gage datum remained the same during the period. During the winter, because of inaccessible location and deep snow, the operation of the gage at the lake was discontinued, and the stage read at staff gage in channel exposed at low tide at beach. The first gage at beach was set at an unknown datum and washed out in winter of 1915–16. Another staff gage was set at about the same location November 24, 1916. Other staff gages were set at about the same location January 11 and November 13, 1918.

DISCHARGE MEASUREMENTS.—Made from cable across outlet of lake, 100 feet downstream from gage and 10 feet upstream from crest of first falls. The rope sling from which discharge measurements were first made was replaced in fall of 1915 by a standard U. S. Geological Survey gaging car, making more reliable measurements possible.

CHANNEL AND CONTROL.—The gage is on left shore of lake, 100 feet upstream from outlet, where the stream becomes constricted into a narrow channel, the bed of which is composed of large boulders and rock outcrops that form a well-defined and permanent control.

EXTREMES OF DISCHARGE.—1913–1919: Maximum stage occurred, probably, on September 26, 1918 (discharge, 2,300 second-feet, estimated by multiplying maximum discharge at Long River on September 27, 1918, by 0.44, which is the ratio between the maximum discharges of Crater Lake outlet and Long River on August 19 and 20, 1917; minimum discharge, 5 second-feet, February 1–13, 1916, estimated from one discharge measurement and by comparison with climatic data, and February 13, 1919.

ACCURACY.—Stage-discharge relation permanent. Rating curve defined by 19 discharge measurements, 13 of which were made by employees of the Speel River Project (Inc.) and 6 by an engineer of the United States Geological Survey, and is well defined below and extended above 1,000 second-feet. Rating curve used January 1 to February 10 for staff gage at beach fairly well defined. Operation of water-stage recorder satisfactory except for July 1–8, when gage clock was run down; gage-height graph August 6 to October 8 lost, when skiff capsized with G. H. Canfield, October 8. Discharge record January 1 to February 10 computed from gage-height record for staff gage at beach. Daily discharge May 23 to August 5 ascertained by applying to rating table daily gage height determined by inspecting gage-height graph, or for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of the day.

Crater Lake is 1,010 feet above sea level and covers 1.1 square miles. The sides of the mountains surrounding the lake are steep and barren, and the tops are covered by glaciers.

Discharge measurements of Crater Lake outlet at Speel River, Port Snettisham, during 1918.

[Made by G. H. Canfield.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
Jan. 11	a1.22	127	Apr. 9	a.74	32
Feb. 16	a.58	10.1	Dec. 4		14.6

a Referred to staff gage at beach, installed Nov. 13, 1918.

Daily discharge, in second-feet, of Crater Lake outlet at Speel River, Port Snettisham, for 1919.

Day.	Jan.	Feb.	May.	June.	July.	Aug.	Oct.	Nov.
1	32	35	....	105	272	532	....	93
2	136	35	....	120	265	472	....	83
3	82	29	....	150	261	429	....	78
4	62	18	....	156	272	416	....	69
5	78	15	....	146	304	472	....	....
6	82	13	....	129	362	....	....	....
7	200	9	....	126	502	....	....	....
8	175	7	....	129	487	....	....	....
9	165	7	....	142	443	....	402	....
10	146	10	....	174	472	....	293	....
11	127	8	....	205	457	....	221	32
12	104	7	....	221	416	....	189	31
13	74	5	....	214	472	....	161	30
14	58	9	....	200	532	....	139	36
15	55	13	....	191	502	....	122	42
16	48	10	....	189	402	....	113	87
17	44	....	....	198	338	....	112	103
18	41	....	....	200	316	....	118	293
19	35	....	....	207	316	....	164	350
20	35	....	....	237	327	....	356	327
21	35	....	....	304	375	....	422	362
22	32	....	....	304	375	....	304	251
23	32	....	126	304	375	....	212	178
24	26	....	120	304	375	....	161	132
25	29	....	142	304	350	....	134	108
26	29	....	145	316	375	....	116	92
27	29	....	126	350	429	....	113	....
28	29	....	112	316	547	....	111	....
29	35	....	103	282	675	....	102	....
30	34	....	100	275	728	....	101	....
31	32	....	100	....	610	....	98	....

NOTE.—Discharge for following periods, for which gage-height records are not available, estimated from records for Sweetheart Falls Creek: Jan. 10, 20, 30, and Feb. 11, daily discharge: Feb. 17-28, 15 second-feet; Mar. 1-31, 12 second-feet; Apr. 1-30, 47 second-feet; May 1-22, 118 second-feet: July 1-8, daily discharge; Aug. 6-31, 520 second-feet; Sept. 1-30, 420 second-feet; Oct. 1-8, 470 second-feet; Nov. 5-10, 25 second-feet; Nov. 27-30, 25 second-feet; and Dec. 1-31, 30 second-feet.

Monthly discharge of Crater Lake outlet at Speel River, Port Snettisham, for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	200	26	68.4	4,210
February	35	5	14.6	811
March	....	....	12	738
April	....	....	47	2,800
May	....	....	118	7,260
June	350	105	217	12,900
July	728	261	417	25,600
August	....	....	511	31,400
September	....	....	420	25,000
October	....	98	259	15,900
November	362	....	101	6,010
December	....	....	30	1,840
The year	....	5	....	134,000

LONG RIVER BELOW SECOND LAKE, AT PORT SNETTISHAM.

LOCATION.—One-half mile downstream from outlet of Second Lake, 1 mile downstream from outlet of Long Lake, one-half mile upstream from head of Indian Lake, 2½ miles by trail and boat across Second Lake from cabins of the Speel River project at head of the North Arm of Port Snettisham, 42 miles by water from Juneau.

DRAINAGE AREA.—33.2 square miles (measured on sheet No. 12 of the Alaska Boundary Tribunal maps, edition of 1895).

RECORDS AVAILABLE.—November 11, 1915, to December 31, 1919.

GAGE.—Stevens continuous water-stage recorder on right bank one-half mile below outlet of Second Lake.

DISCHARGE MEASUREMENTS.—At medium and high stages made from cable across river at gage; at low stages made by wading one-fourth mile downstream.

CHANNEL AND CONTROL.—At the gage the channel is deep and the current sluggish; banks are low and are overflowed at extremely high stages; bed smooth except for one large boulder. A rapid, 500 feet downstream, forms a well-defined and permanent control.

EXTREMES OF DISCHARGE.—Maximum stage during year probably occurred October 6, but stage is unknown as gage-height graph July 9 to October 8 was lost; minimum flow 35 second-feet, March 29.

1916–1918: Maximum stage, 10.2 feet September 27, 1918 (discharge, estimated from extension of rating curve, 5,300 second-feet); minimum flow, 23 second-feet, February 13, 1916.

ICE.—Stage-discharge relation affected by ice during January, February, March, and April.

ACCURACY.—Stage-discharge relation permanent; affected by ice or poor connection between well and river January 16 to February 27, March 6 to April 2, April 9–15, November 1–14, and December 4. Rating curve fairly well defined between 50 and 400 second-feet and well defined between 400 and 2,000 second-feet. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Gage-height graph July 9 to October 8, lost on October 8, when skiff capsized with G. H. Canfield. Daily discharge ascertained by applying to the rating table daily gage height determined by inspecting the gage-height graph. Records good except for stages below 400 second-feet and periods of break in gage-height record, for which they are roughly approximate.

The area draining to Long River between Long Lake outlet and this station comprises only 1.3 square miles, including First Lake and Second Lake. Because this area is at a low altitude and has no glaciers the run-off per square mile from it is greater early in the spring but much less in summer than that from the area above Long Lake, which is partly covered by glaciers.

Discharge measurements of Long River below Second Lake, at Port Snettisham, during 1919.

[Made by G. H. Canfield.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
Jan 10	2.40	345	July 8	4.03	920
Apr. 9	[a]1.74	88	Dec. 4	1.00	63

[a] Stage of water surface in well; connection between well and river obstructed.

Daily discharge, in second-feet, of Long River below Second Lake, at Port Snettisham, for 1919.

Day.	Jan.	May.	June.	July.	Oct.	Nov.	Dec.
1	100		317	630		125	76
2	230		360	600		115	70
3	280		411	565		106	66
4	175		411	630		95	63
5	260		390	720		85	
6	500		360	900		80	
7	670		360	1,070		75	
8	720		372	970		72	
9	550		405		975	70	
10	345		474		660	68	
11	351		530		495	65	
12	252		548		405	62	
13	198		548		317	80	
14	171		512		257	130	
15	146		495		207	211	
16			495		186	317	
17			512		190	339	
18			512		252	495	
19			530		301	505	
20			600		520	530	
21			680		660	565	
22		420	700		480	414	
23		390	720		345	290	
24		366	720		259		141
25		411	710		204		267
26		405	770		171		290
27		360	820		170		239
28		331	750		232		185
29		309	680		175		150
30		290	650		149		130
31		304			141		115

NOTE.—Owing to ice effect or obstruction in connection between gage well and river, discharge was estimated for following periods from current-meter measurement of Apr. 9 and comparison with weather records for Juneau and hydrograph of Sweetheart Falls Creek: Jan. 1–9, daily discharge shown in table Jan. 16–31, 95 second-feet; Feb. 1–28, 55 second-feet; Mar. 1–31, 50 second-feet; Apr. 1–30, 125 second-feet May 1–21, 285 second-feet. Daily discharge, June 25 to July 7 determined from gage-height graph drawn through maximum amd minimum stages shown by recorder and by comparison with graph for Sweetheart Falls Creek. Discharge for following periods estimated from records for Sweetheart Falls Creek owing to loss of gage-height record: July 9–31, 900 second-feet; Aug. 1–31, 1,050 second-feet; Sept. 1–30, 1,000 second-feet; Oct. 1–8, 1,070 second-feet. Daily discharge Nov. 1–14, Dec. 1–3, and mean discharge Nov. 24–30 (125 second-feet) estimated from records for Sweetheart Falls Creek. Mean discharge, Dec. 5–23 (115 second-feet), and daily discharge, Dec. 28–31, estimated from maximum and minimum stages shown by recorder and by comparison with records for Sweetheart Falls Creek.

Monthly discharge of Long River below Second Lake, at Port Snettisham, for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	720		209	12,900
February			55	3,050
March			50	3,070
April			125	7,440
May			309	19,000
June	820	317	545	32,400
July			864	53,100
August			1,050	64,600
September			1,000	59,500
October		141	526	32,300
November	565	62	192	11,400
December		63	128	7,870
The year			424	307,000

GRINDSTONE CREEK AT TAKU INLET.

LOCATION.—On north shore of Taku Inlet, between Point Bishop and Point Salisbury, one-fourth mile west of mouth of Rhine Creek and 11 miles by waterfrom Juneau.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—May 6, 1916, to December 31, 1919.

GAGE.—Stevens continuous water-stage recorder on left bank, 200 feet from tidewater, installed September 16, 1916. A Lietz seven-day graph water-stage recorder was used May 6 to June 17, 1916.

DISCHARGE MEASUREMENTS.—At all stages made by wading either in the channel on the beach, which is exposed at low tide, or 100 feet below gage at high tide.

CHANNEL AND CONTROL.—For a distance of one-fourth mile from tidewater the stream descends in a series of rapids and falls through a narrow, rocky channel. The gage is at upper end of a turbulent pool between two falls, the lower of which forms a well-defined control. When gage was installed logs were jammed in channel near upper end of pool.

EXTREMES OF DISCHARGE.—Maximum stage during year, from water-stage recorder, 4.2 feet at 5 p. m. October 3 (discharge, estimated from extension of rating curve, 330 second-feet); minimum discharge, 3 second-feet March 16–20, estimated by comparison with climatic data.

1916–1919: Maximum stage, 6 feet at 7 p. m. September 26, 1918 (discharge, estimated from an extension of the rating curve, 700 second-feet); minimum stage, –0.24 foot April 5–7, 1918 (discharge, 2.6 second-feet).

ICE.—Stage-discharge relation sometimes affected by ice.

ACCURACY.—Stage-discharge relation permanent. Rating curve, revised by measurements made during 1919, well defined below 150 second-feet; extended above 150 second-feet by estimation. Operation of water-stage recorder satisfactory except for periods shown in the footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of day. Records good except those for periods of break in record and discharge above 150 second-feet, which are poor.

Discharge measurements of Grindstone Creek at Taku Inlet during the year ending Sept. 30, 1918.

[Made by G. H. Canfield.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
Jan. 20	[a] 0.59	11.6	Apr. 22	0.59	16.0
23	[a] .43	11.0	July 7	1.71	114
Feb. 21	.15	6.1	Dec. 13	[b] .40	10.6
Mar. 22	–.05	3.8			

[a] Control partly obstructed by ice. [b] Ice cover arched over control; no backwater.

Daily discharge, in second-feet, of Grindstone Creek at Taku Inlet for 1919.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	17	10	3.5	....	19	29	47	52	35	40	19	13
2	25	9.5	3.5	....	18	41	45	47	30	85	18	15
3	19	9.0	3.0	....	17	61	67	46	26	184	17	15
4	17	9.0	3.0	....	17	64	69	48	24	130	....	13
5	19	8.0	3.0	....	17	55	73	50	24	260	....	12
6	45	7.5	3.5	....	18	48	128	46	22	189	....	12
7	40	8.0	4.0	....	19	42	130	40	22	124	....	....
8	56	8.0	3.5	....	26	39	92	71	21	87	....	....
9	38	7.5	3.0	....	34	44	92	67	48	70	....	....
10	30	7.5	3.5	....	30	59	89	48	60	60	....	....
11	28	7.5	3.5	....	28	64	80	43	34	51	....	....
12	24	7.0	3.5	....	32	56	74	39	34	45	....	....
13	20	7.0	3.5	....	31	55	79	41	116	41	....	11
14	18	7.0	3.5	....	36	52	83	57	69	36	....	10
15	17	7.0	3.5	....	44	49	71	50	50	32	....	8.0
16	16	7.0	3.0	....	48	49	61	51	43	33	....	9.5
17	14	7.0	3.0	....	43	51	57	43	....	28	....	22
18	11	7.5	3.0	....	44	50	70	43	....	38	....	34
19	11	8.0	3.0	....	48	51	62	85	....	48	....	16
20	12	7.5	3.0	....	48	70	62	79	....	48	....	14
21	12	7.0	3.5	....	41	71	60	54	....	43	....	13
22	14	6.5	4.0	17	38	66	54	45	....	32	28	13
23	11	5.5	....	18	34	59	52	37	....	28	23	15
24	11	5.0	....	19	37	53	49	34	....	25	18	16
25	11	4.5	....	30	38	54	45	31	....	24	17	18
26	11	4.0	....	52	36	70	51	28	80	23	17	27
27	11	3.5	....	43	32	71	59	43	64	27	18	19
28	10	3.5	....	34	29	61	64	38	60	24	16	16
29	10	....	....	26	28	54	74	61	52	22	15	15
30	10	....	....	24	28	49	70	52	45	22	14	16
31	10	....	....	....	29	....	57	43	....	21	....	16

NOTE.—Discharge for following periods estimated by comparison with records of flow for other stations, because stage-discharge relation was affected by ice: Jan. 19–25, Feb. 25–28, and Mar. 1–21, as shown in table. Operation of water-stage recorder not satisfactory for following periods, discharge estimated from maximum and minimum stages indicated by recorder and by comparison with records of flow for other stations: Mar. 22–31, 5 second-feet; Apr. 1–21, 15 second-feet; Sept. 17–25, 120 second-feet; Nov. 4–21, 25 second-feet; and Dec. 7–12, 11 second-feet.

Monthly discharge of Grindstone Creek at Taku Inlet for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	56	10	19.3	1,190
February	10	3.5	7.00	389
March	....	3.0	3.82	235
April	52	....	19.3	1,150
May	48	17	31.8	1,960
June	71	29	54.6	3,250
July	130	45	69.9	4,300
August	85	28	48.8	3,000
September	....	21	68.0	4,050
October	260	21	61.9	3,810
November	....	14	22.3	1,330
December	34	8.0	14.7	904
The year	260	3.0	35.3	25,600

CARLSON CREEK AT SUNNY COVE.

Location.—At Sunny Cove, on west shore of Taku Inlet, 20 miles by water from Juneau.

Drainage area.—22.26 square miles (determined by engineering department of Alaska Gastineau Mining Co. from surveys made by that company).

Records available.—July 18, 1916, to December 31, 1919.

Gage.—Stevens water-stage recorder on left bank, 2 miles from tidewater; inspected several times a week by employees of Alaska Gastineau Mining Co.

Discharge measurements.—At high stages, made from cable across river one-half mile downstream from gage; at medium and low stages, made by wading 500 feet upstream from gage.

Channel and control.—Above the gage the stream meanders in one main channel and several small channels through a flat, sandy basin about a mile long; just below the gage the channel contracts and the stream passes over rocky falls that form a well-defined and permanent control. The point of zero flow is at gage height −1.5 feet.

Extremes of discharge.—Maximum stage recorded during year, 6.75 feet at 4 p. m. September 13 (discharge, from extension of rating curve, 4,440 second-feet); minimum flow, estimated by comparison with record of flow for Sweetheart Falls, 15 second-feet, March 28.

1916–1919: Maximum stage, 8.1 feet at 2 p. m. September 26, 1918 (discharge, computed from extension of rating curve, 6,200 second-feet); minimum flow, estimated from climatic data and hydrographs for streams in near-by drainage basins, 10 second-feet, April 1–7, 1918.

Ice.—Stage-discharge relation affected by ice.

Accuracy.—Stage-discharge relation permanent. Rating curve well defined between 70 and 2,000 second-feet, extended below 70 second-feet to point of zero flow and above 2,000 second-feet by estimation. Operation of water-stage recorder satisfactory except for periods of break in record as indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of the day. Records good except for stages below 70 second-feet and above 2,000 second-feet and for periods of break in record, for which they are fair.

Discharge measurements of Carlson Creek at Sunny Cove during 1919.

[Made by G. H. Canfield.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
Jan. 23		[a] 40	Apr. 22	−0.30	76
Feb. 21		[a] 24	Aug. 12	1.70	474
Mar. 22		[a] 20	Dec. 13		[a] 33

[a] Creek covered with thick ice. Measurement made 2 miles below gage; measured discharge reduced 5 per cent to obtain flow at gage.

Daily discharge, in second-feet, of Carlson Creek at Sunny Cove for 1919.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.
1		367	605	590	175	104	
2		399	560	560	137	288	
3		530	658	545	120	1,100	
4		455		658	108	1,080	
5		387		762	102	1,860	
6		370		590	108	3,160	
7		419		530	127	1,270	
8		425		658	128	441	
9		500		840	452	272	
10		622		622	1,020	182	
11		640		530	362	124	
12		575		470	485	114	
13		605		581	3,150	107	33
14		545		1,450	999	107	
15		530		885	470	104	
16		515		860	382	101	
17		575		622	1,040	104	
18		545		622	1,210	136	
19		575		1,510	540	256	
20		710		902	440	455	
21		780		500	2,030	455	
22		710		359	662	156	
23		675		300	636	102	
24	340	728	575	272	1,460		
25	545	762	590	263	1,170		
26	402	762	675	250	396		
27	315	745	820	382	210		
28	277	692	950	590	115		
29	268	675	1,020	745	156		
30	292	605	745	500	106		
31	325		622	272			

NOTE.—Operation of water-stage recorder unsatisfactory and discharge for following periods estimated from four current-meter measurements, weather records, and hydrographs for other stations: Jan. 1–31, 137 second-feet; Feb. 1–28, 28 second-feet; Mar. 1–31, 20 second-feet; Apr. 1–23, 65 second-feet: Apr. 24–30, 200 second-feet; and May 1–23, 320 second-feet. July 4–23, estimated at 675 second-feet by comparison with record of flow for Sweetheart Falls Creek. Discharge for following periods estimated by comparison with records for other stations: Oct. 20–23, daily discharge; Oct. 24–31, 85 second-feet; Nov. 1–30, 130 second-feet; Dec. 1-12, 45 second-feet; Dec. 14–31, 150 second-feet.

Monthly discharge of Carlson Creek at Sunny Cove for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January			137	8,420
February			28	1,560
March			20	1,230
April			96.5	5,740
May			327	20,100
June	780	367	581	34,600
July	1,020		688	42,300
August	1,510	250	620	38,100
September	3,150	102	617	36,700
October	3,160		412	25,300
November			130	7,740
December			106	6,520
The year				228,000

SHEEP CREEK NEAR THANE.

LOCATION.—At lower end of flat basin, above diversion dam for flume leading to Treadwell power house at beach and 1 mile by tramway and ore railway from Thane.

DRAINAGE AREA.—4.57 square miles above gaging bridge (measured on United States Geological Survey map of Juneau and vicinity, edition of 1917).

RECORDS AVAILABLE.—July 26, 1916, to December 31, 1919.

GAGE.—Stevens water-stage recorder on right bank, at pool formed by an artificial control just below small island three-tenths mile upstream from diversion dam. Recorder inspected once a week by an employee of the Alaska Gastineau Mining Co.

DISCHARGE MEASUREMENTS.—At extremely high stages, made from gaging bridge two-tenths mile downstream from gage; at low stages, made by wading near bridge section. No streams enter between gage and measuring section, but seepage inflow ranges from a small amount to 10 per cent of total flow, the percentage of inflow usually being large after periods of heavy precipitation.

CHANNEL AND CONTROL.—The station is near the lower end of a flat basin through which the stream meanders in a channel having low banks and a bed of sand and gravel. An artificial control was built 2 feet below the intake for the gage well, to confine the flow in one channel during high water and to insure a permanent stage-discharge relation. The spillway of the control at low stages consists of a timber, 16 feet long, set in the bed of the stream. During medium and high stages another timber, 8 feet long, bolted at the top near the right end, forms part of the control. A 3-foot cut-off wall is driven at the upstream face of the spillway. There are wing walls at each end, and an 8-foot apron extends downstream from the control.

ICE.—Control covered with ice and snow for short period.

EXTREMES OF DISCHARGE.—Maximum stage during year, 2.52 feet, at 1 a. m. October 6 (discharge, estimated from extension of rating curve, 490 second-feet); minimum stage, −0.48 foot March 31 to April 2 (discharge, 4.0 second-feet).

1916–1919: Maximum stage during period, 3.5 feet, at 2 p. m. September 26, 1918 (discharge, estimated from extension of rating curve, 820 second-feet); minimum flow, 1.0 second-foot, April 6–8, 1917.

ACCURACY.—Stage-discharge relation, between 0.5 and 1.2 feet, changed January 8. Rating curve used January 1–8, fairly well defined below 700 second-feet; curve used January 9 to December 31 fairly well defined. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of the day. Records fair.

Discharge measurements of Sheep Creek near Thane during 1919.

[Made by G. H. Canfield.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
Jan. 25	0.66	18	July 1	1.00	74
Feb. 11	.30	9.0	Aug. 20	1.135	105
Mar. 20	−.40	4.5	Oct. 22	.86	43
Apr. 17	.65	16	Dec. 11	.53	13
May 13	.92	52			

Daily discharge, in second-feet, of Sheep Creek near Thane for 1919.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	22	13	6.5	4.0	41	61	72	72	41	46	19	......
2	22	11	6.4	4.0	35	......	72	63	36	72	18	......
3	21	9.3	6.3	4.9	32	......	96	61	35	210	17	......
4	19	9.2	6.2	5.9	31	72	108	68	34	164	17	......
5	16	9.0	6.0	7.0	30	70	108	72	34	322	16	......
6	38	8.5	......	8.3	30	84	124	68	32	379	15	......
7	68	8.4	......	9.0	34	88	134	61	34	232	15	......
8	75	8.3	......	12	50	......	108	72	34	146	15	......
9	63	8.1	......	15	61	......	108	91	68	111	14	......
10	54	8.0	......	16	52	......	115	77	103	91	14	......
11	48	7.9	......	16	50	......	108	70	54	......	14	13
12	46	7.8	......	16	52	......	105	63	56	......	13	13
13	41	7.7	......	16	54	......	113	72	244	......	13	12
14	38	7.6	......	17	63	......	115	113	121	......	13	12
15	35	7.5	......	18	86	......	103	96	88	......	19	12
16	31	7.3	......	18	91	......	91	96	72	......	......	12
17	27	7.2	......	17	79	......	88	77	96	......	......	15
18	23	7.1	......	18	82	......	94	72	98	......	......	25
19	21	7.1	......	18	96	......	91	141	84	......	......	15
20	19	7.0	4.5	19	96	......	88	113	79	......	......	16
21	19	6.9	4.5	22	84	......	86	88	251	......	68	16
22	19	6.8	4.4	22	77	......	82	77	113	43	52	16
23	19	6.7	4.4	25	72	......	79	68	108	40	38	15
24	18	6.6	4.3	23	72	......	77	61	252	40	25	15
25	18	6.6	4.3	61	84	......	77	59	176	36	......	19
26	18	6.6	4.2	84	77	......	77	52	121	34	......	35
27	17	6.6	4.2	86	68	......	86	63	94	34	......	26
28	16	6.6	4.1	68	61	......	96	68	72	32	......	22
29	16	......	4.1	59	54	......	108	88	68	27	......	19
30	16	......	4.0	50	54	......	98	68	56	26	......	17
31	15	......	4.0	......	54	......	79	54	......	23	......	18

NOTE.—Daily discharge Jan. 10–24 and Mar. 1–5 estimated, because of unsatisfactory operating of gage by comparison with records for Gold Creek. Discharge for following periods estimated from maximum and minimum stages shown by gage and comparison with records of flow for Gold Creek: Mar. 6–19, 5 second-feet; June 2–3, 80 second-feet; June 8–30, 90 second-feet; Oct. 11–21, 53 second-feet; Nov. 16–20, 60 second-feet; Nov. 25–30, 22 second-feet; Dec. 1–10, 18 second-feet; Dec. 30 and 31 as shown in table.

Monthly discharge of Sheep Creek near Thane for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	75	15	29.6	1,820
February	13	6.6	7.87	437
March	....	....	4.92	303
April	86	4.0	25.3	1,510
May	96	30	61.4	3,780
June	....	....	86.8	5,160
July	134	72	96.3	5,920
August	141	52	76.3	4,690
September	252	32	91.8	5,460
October	379	23	86.8	5,340
November	....	13	28.2	1,680
December	35	....	17.5	1,080
The year	379	....	51.3	37,200

GOLD CREEK AT JUNEAU.

LOCATION.—At highway bridge at lower end of Last Chance basin, 200 feet upstream from diversion dam of Alaska Electric Light & Power Co. and one-fourth mile from Juneau.

DRAINAGE AREA.—9.47 square miles (determined by engineering department of Alaska Gastineau Mining Co. from surveys made by that company).

RECORDS AVAILABLE.—July 20, 1916, to December 31, 1919.

GAGE.—Stevens continuous water-stage recorder on left bank at upstream side of highway bridge. A staff gage was installed September 19, 1916, on left wing wall of diversion dam 200 feet downstream and used in determining the time of changes in stage-discharge relation at the well gage.

DISCHARGE MEASUREMENTS.—At medium and high stages made from gaging bridge suspended, at right angles to current, from floor of highway bridge; at low stages, made by wading near gage.

CHANNEL AND CONTROL.—Station is at lower end of a flat gravel basin three-fourths mile long. For 20 feet upstream from gage the stream is confined between the abutments of an old bridge, and for 15 feet downstream it is confined between the abutments of present bridge. For a distance of 130 feet farther downstream the stream is confined in a narrow channel which is not subject to overflow. Because of the steep gradient of channel opposite and for 150 feet below gage, a short stretch of the channel immediately below the gage acts as the control. The operation of the headgates of flume at diversion dam, 200 feet downstream, does not affect the stage-discharge relation at gage, but the swift current during high stages shifts the gravel in bed of stream, thereby causing changes in the stage-discharge relation.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year, 4.9 feet at 2 p. m., September 13 (discharge, computed from extension of rating curve, 1,300 second-feet); minimum flow, estimated by discharge measurements and climatic data, 2 second-feet, March 15–28.

1916–1919: Maximum stage, 6.8 feet September 26, 1918 (discharge estimated from extension of rating curve, 2,600 second-feet); minimum discharge, 0.9 second-foot March 26, 1918.

ICE.—Stage-discharge relation affected by ice in February, March, and April.

DIVERSION.—Water diverted at several points upstream for power development is returned to creek above gage, except about 20 second-feet for seven months (when there is a surplus over amount used by Alaska Electric Light & Power Co., which has prior right) and 1 second-foot the remainder of year, used by the Alaska-Juneau Gold Mining Co. A dam 200 feet downstream diverts water into the flume of the Alaska Electric Light & Power Co.

REGULATION.—No storage or diversions above station regulate the flow more than a few hours in low water.

ACCURACY.—Stage-discharge relation changed during periods of high water; 13 discharge measurements were made during year, by use of which rating curves have been constructed applicable as follows: January 1 to June 21, well defined below and fairly well defined above 70 second-feet; June 22 to September 13, fairly well defined; September 14–24 (a. m.), poorly defined by one discharge measurement; September 24 (p. m.) to November 17, fairly well defined by two discharge measurements; November 18 to December 31, fairly well defined by two discharge measurements. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuations, by averaging results obtained by applying to rating table mean gage heights for equal intervals of the day. Records fair.

Discharge measurements of Gold Creek at Juneau during 1919.

[Made by G. H. Canfield.]

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Sec.-ft.*		*Feet.*	*Sec.-ft.*		*Feet.*	*Sec.-ft.*
Jan. 24	0.89	14.5	May 10	1.37	59	Nov. 19	1.35	116
Feb. 10	.78	10.5	July 1	1.88	162	28	.71	24
Mar. 14	[a] .70	2.1	Aug. 6	1.86	151	Dec. 27	.92	46
Apr. 4	[a] .98	17.0	Sept. 15	2.16	173			
18	.92	14.6	Oct. 15	1.08	46			

[a] Control and measuring section frozen over.

Daily discharge, in second-feet, of Gold Creek at Juneau for 1919.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	16	12	......	......	48	88	158	167	78	42	16	20
2	22	11	......	......	39	109	153	147	70	93	15	21
3	19	11	......	......	32	137	231	140	63	410	14	20
4	18	11	......	......	27	118	270	169	63	320	14	19
5	20	10	......	......	22	109	255	198	63	615	14	19
6	45	10	......	......	......	95	300	158	63	725	13	19
7	71	10	......	......	......	95	330	132	70	304	13	17
8	86	10	......	......	......	97	246	174	70	114	13	16
9	62	10	......	......	......	114	270	216	151	73	13	14
10	55	10	......	......	59	147	285	180	240	50	12	14
11	46	......	......	......	55	158	285	162	111	47	12	12
12	34	......	......	......	62	161	264	141	147	39	12	12
13	31	......	......	......	62	170	309	162	920	35	20	12
14	27	......	......	......	77	143	340	285	295	30	18	12
15	25	......	......	......	118	137	276	228	188	46	18	12
16	21	......	......	......	137	143	208	202	165	30	18	16
17	19	......	......	......	109	147	185	162	289	37	46	41
18	19	......	......	......	109	137	216	174	273	32	230	72
19	19	......	......	......	147	161	210	365	154	42	125	33
20	19	......	......	......	152	215	198	285	135	57	134	22
21	16	......	......	......	118	240	205	174	490	93	99	19
22	14	......	......	......	99	225	195	140	183	73	63	17
23	14	......	......	......	92	210	195	130	172	42	45	25
24	14	......	......	......	106	210	180	130	470	32	30	42
25	14	......	......	......	122	210	162	130	320	30	29	53
26	14	......	......	......	102	222	198	115	165	28	30	93
27	14	......	......	......	84	225	225	158	109	31	29	49
28	13	......	......	......	77	198	255	174	93	26	27	36
29	13	......	......	......	72	180	300	198	91	22	25	29
30	13	......	......	......	71	167	255	140	60	21	22	25
31	12	......	......	......	77	......	190	115	......	20	......	27

NOTE.—Water-stage record lost for following periods; discharge estimated from three discharge measurements, from climatic records for Juneau, and by comparison with hydrographs or other stations: Feb. 11–28, 9 second-feet; Mar. 1–31, 5 second-feet; and Apr. 1–30, 35 second-feet. Operation of water-stage recorder unsatisfactory for following periods, discharge estimated by comparison with records for Sheep Creek: May 6–9, 50 second-feet; Aug. 11–20, as shown in table.

Monthly discharge of Gold Creek at Juneau for 1919.

Month.	Discharge in second-feet.			Run-off in acre-feet.
	Maximum.	Minimum.	Mean.	
January	86	12	26.6	1,640
February	......	......	9.54	530
March	......	......	5	307
April	......	......	35	2,080
May	152	22	79.8	4,910
June	240	88	159	9,460
July	340	153	237	14,600
August	365	115	176	10,800
September	490	60	192	11,400
October	725	20	115	7,070
November	230	12	39.0	2,320
December	93	12	27.0	1,660
The year	725	......	92.2	66,800

FALLS CREEK AT NICKEL, NEAR CHICHAGOF.

LOCATION.—One-eighth mile above beach, on stream that enters tidewater half a mile northeast of camp of Alaska Nickel Mines Co., 20 miles by water northwes of Chichagof, on west coast of Chichagof Island.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—May 6, 1918, to December 31, 1919.

GAGE.—Stevens water-stage recorder on left bank one-eighth mile above beach.

DISCHARGE MEASUREMENTS.—At medium and high stages, made from cable across stream 500 feet above gage; at low stages, made by wading in channel exposed at beach at low tide.

CHANNEL AND CONTROL.—The gage is 20 feet upstream from rectangular weir, the crest of which is 2 feet above bed of stream, 2 inches wide, and 40 feet long. At the cable section the bed is smooth, the water is deep, and the current is regular and sluggish.

EXTREMES OF STAGE.—Maximum stage recorded during period, 3.45 feet at 3 p. m. September 26, 1918; minimum stage recorded, 0.18 foot March 12, 1919.

ICE.—Stage-discharge relation affected by ice forming on crest of weir.

ACCURACY.—Stage-discharge relation permanent; affected by ice January 18, February 25 to March 4, 1918. Sufficient discharge measurements not yet available to define rating curve. Operation of water-stage recorder satisfactory except for following periods; November 24–30, December 29, 1918, January 18, to February 8, March 23 to April 3, April 28 to May 3, May 4 to 17, July 22–27, August 11–15, September 24, and December 17–27, 1919. Mean daily gage height determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging mean gage heights for regular intervals of the day.

COOPERATION.—The gage and weir were installed by the Alaska Nickel Mines Co., and the cable and car by the United States Geological Survey in cooperation with the company which also furnished the gage-height record and most of the discharge measurements.

Discharge measurements of Falls Creek at Nickel during 1918–19.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
1918.		*Feet.*	*Sec.-ft.*	1919.		*Feet.*	*Sec.-ft.*
June 10	G. H. Canfield	0 92	90	Jan. 19	Kimball	[b] 0.70	23
11	....do	.96	100	Feb. 21	....do	[b] .44	24
July 8	F. S. Fleming [a]	.52	38				
Dec. 30	Kimball [a]	.56	48				

[a] Employee of Alaska Nickel Mines Co.
[b] Stage-discharge relation affected by ice.

Daily gage height, in feet, of Falls Creek at Nickel for 1918–19.

Day	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1918.								
1	......	1.07	1.01	0.59	1.60	0.62	1.15	1.70
2	......	.94	.86	.55	1.10	.60	.89	1.42
3	......	.86	.77	.51	.70	.76	.73	1.07
4	......	.81	.71	.48	.55	.78	.87	.87
5	......	.81	.65	.46	.50	.69	2.70	.79
6	1.10	.84	.59	.53	.45	.62	2.25	.98
7	.92	.91	.56	.67	.43	.67	1.48	.70
8	.87	.99	.54	.60	.40	.60	1.07	.61
9	......	1.00	.52	.63	.83	.65	.84	.57
10	.87	.93	.49	.53	.68	.52	.70	.52
11	.94	.95	.66	.50	.60	.50	.73	.48
12	.98	.93	.68	.48	.55	.95	.88	.45
13	.98	.87	.60	.62	.52	.87	.75	.42
14	.97	.83	.55	.97	.48	1.10	.70	.43
15	.92	.81	.51	.75	.60	.88	.60	.41
16	.88	.75	.48	.75	.70	.75	.59	.67
17	.82	.70	.46	.92	1.39	.88	.54	.75
18	.83	.67	.44	.78	1.70	.98	.46	.68
19	.77	.63	.42	.75	1.30	.80	.43	.62
20	.70	.67	.42	.78	.97	.78	.57	.54
21	.75	.65	.40	1.03	.78	.72	.75	1.23
22	.70	.61	.38	1.20	.65	.62	.83	1.20
23	.70	.60	.37	1.33	.93	.59	.85	1.30
24	.70	.66	.37	1.61	.75	.65	......	1.08
25	.73	.71	.36	1.43	1.36	.62	......	1.16
26	.76	.73	.35	1.15	2.48	1.07	......	1.07
27	.77	.75	.46	1.00	1.87	.88	......	.85
28	1.54	.75	.63	1.26	1.27	1.30	......	.70
29	1.81	1.07	.50	1.30	.95	1.18	......	......
30	1.51	1.33	.55	2.24	.73	1.28	......	.56
31	1.34	......	.66	2.46	......	1.20	......	.52

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1919.												
1	0.57	......	0.76	......	......	0.61	0.45	0.36	0.78	0.58	0.63	0.39
2	1.07	......	.68	......	......	.66	.44	.35	.62	1.73	.51	.36
3	.90	......	.63	......	......	.69	.48	.34	.54	2.6	.46	.36
4	.82	......	.56	0.71	0.53	.67	.52	.34	.48	2.3	.43	.37
5	.92	......	.26	.75	......	.66	.52	.42	.42	2.3	.38	.45
6	1.64	......	.30	.75	......	.65	.63	.37	.39	2.8	.35	.65
7	1.57	......	.31	.68	......	.62	.60	.35	.38	2.00	.33	.49
8	1.45	......	.33	.65	......	.58	.57	.55	.36	1.32	.40	.47
9	1.15	0.37	.45	.64	......	.58	.60	.75	1.02	.95	.33	.70
10	.96	.45	.37	.57	......	.57	.76	.65	1.05	.94	.30	.72
11	.86	.37	.33	.55	......	.57	.78	......	.80	.77	.30	.60
12	.71	.34	.23	.52	......	.57	.76	......	1.48	.68	.33	.50
13	.65	.35	.35	.52	......	.60	.88	......	2.73	.64	.64	.44
14	.60	.39	.55	.52	......	.62	.88	......	1.95	.56	.52	.34
15	.52	.38	.65	.49	......	.62	.76	......	1.25	.50	.67	.55
16	.48	.36	.70	.46	......	.58	.66	.78	1.00	.55	.71	1.12
17	.82	.37	.67	.59	......	.56	.62	.70	1.28	.53	1.00	......
18	......	.62	.68	.67	.81	.55	.63	.80	1.40	.72	1.54	......
19	......	.66	.57	.75	.96	.56	.59	1.20	1.05	.70	1.34	......
20	......	.52	.80	.75	1.24	.60	.61	1.15	.93	1.29	1.50	......
21	......	.46	1.07	.72	1.04	.60	.63	.85	1.65	1.16	1.09	......
22	......	.45	.81	.66	.89	.60	......	.70	1.19	.88	.87	......
23	......	.39	......	.74	.78	.60	......	.60	1.08	.72	.70	......
24	......	.35	......	.71	.80	.58	......	.55	......	.64	.59	......
25	......	.34	......	1.41	.88	.56	......	.46	1.60	.57	.52	......
26	......	.29	......	1.68	.80	.53	......	.42	1.13	.59	.48	......
27	......	.45	......	1.65	.74	.51	......	.58	.85	.62	.46	......
28	......	.65	......	......	.74	.51	.40	.75	.85	.56	.45	.66
29	......	......	......	......	.69	.49	.37	1.02	.75	.57	.46	.60
30	......	......	......	......	.64	.47	.36	1.08	.66	1.10	.41	1.34
31	......	......	......	......	.61	......	.36	.98	......	.70	......	......

NOTE.—For following periods water-stage recorder did not operate satisfactorily, but maximum and minimum stages were recorded: Nov. 24–30, 1918: Maximum stage, 1.90 feet; minimum, 0.83 foot. Jan. 18 to Feb. 8: Maximum stage, 0.88 foot; minimum, 0.83 foot. Mar. 23 to Apr. 3: Maximum stage, 0.90 foot; minimum, 0.22 foot.

PORCUPINE CREEK NEAR NICKEL.

LOCATION.—Half a mile above beach, on stream that enters tidewater at head of Porcupine Harbor, 4 miles northwest of camp of Alaska Nickel Mines Co., which is 20 miles by water northwest of Chichagof, on west coast of Chichagof Island.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—May 20, 1918, to December 31, 1919.

GAGE.—Stevens water-stage recorder on left bank of stream half a mile above beach.

DISCHARGE MEASUREMENTS.—At medium and high stages, made from cable across stream 150 feet above gage; at low stages, made by wading near control.

CHANNEL AND CONTROL.—The gage is located at edge of deep pool formed by contraction of channel where stream passes over exposed bedrock and descends in a series of small falls. The head of these falls forms a well-defined and permanent control. At the cable section the bed is rough, the water is deep, and the current is sluggish and irregular, because 15 feet above cable the stream widens into a small lake.

EXTREMES OF STAGE.—1918-19: Maximum stage recorded during period, 3.35 feet at 10 a. m. November 6, 1918; minimum stage recorded, 0.37 foot March 19 and 28, 1919.

ICE.—Stage-discharge relation not affected by ice.

ACCURACY.—Stage-discharge relation permanent, affected by ice only February 25. Sufficient discharge measurements not yet available to define rating curve. Operation of water-stage recorder satisfactory except for following periods: July 22 to August 4, November 30 to December 23, 1918, May 10–13, July 26–30, October 5–8, 24–31, and December 1–17, 1919. Mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging mean gage heights for regular intervals of the day.

COOPERATION.—The gage was installed by the Alaska Nickel Mines Co., and the cable and car by the United States Geological Survey in cooperation with the company, which also furnished gage-height graph and 4 discharge measurements.

Discharge measurements of Porcupine Creek near Nickel during 1918–19.

Date.	Made by—	Gage height.	Discharge.	Date.	Made by—	Gage height.	Discharge.
1918.		*Feet.*	*Sec.-ft.*	1919.		*Feet.*	*Sec.-ft.*
June 12	G. H. Canfield	1.60	140	Jan. 16	Kimball	1.30	112
Aug. 5	F. S. Fleming	.96	68	25	do	.94	69
				Mar. 1	do	.53	36

Daily gage height, in feet, of Porcupine Creek near Nickel for 1918–19.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1918.								
1	....	1.88	1.59	....	2.35	1.70	1.83	....
2	....	1.78	1.54	....	2.05	1.60	1.73	....
3	....	1.70	1.50	....	1.84	1.62	1.60	....
4	....	1.64	1.45	....	1.69	1.62	1.53	....
5	....	1.59	1.40	0.96	1.57	1.55	2.47	....
6	....	1.59	1.35	.98	1.47	1.48	3.25	....
7	....	1.59	1.33	1.07	1.37	1.44	2.8	....
8	....	1.63	1.30	1.10	1.29	1.43	2.40	....
9	....	1.64	1.27	1.08	1.24	1.38	2.10	....
10	....	1.62	1.25	1.05	1.35	1.32	1.85	....
11	....	1.62	1.28	1.02	1.31	1.28	1.72	....
12	....	1.60	1.30	1.08	1.30	1.41	1.67	....
13	....	1.55	1.26	1.25	1.25	1.47	1.58	....
14	....	1.53	1.22	1.22	1.20	1.53	1.52	....
15	....	1.52	1.20	1.22	1.14	1.51	1.45	....
16	....	1.48	1.18	1.32	1.23	1.46	1.40	....
17	....	1.44	1.15	1.32	1.50	1.45	1.33	....
18	....	1.41	1.13	1.29	1.80	1.55	1.25	....
19	....	1.37	1.10	1.32	1.80	1.52	1.20	....
20	....	1.36	1.08	1.40	1.68	1.48	1.22	....
21	1.24	1.34	1.04	1.55	1.57	1.43	1.27	....
22	1.23	1.30	....	1.65	1.48	1.35	1.38	....
23	1.22	1.28	....	1.86	1.52	1.30	1.38	....
24	1.20	1.28	....	1.91	1.45	1.30	1.42	1.46
25	1.20	1.30	....	1.85	1.70	1.27	1.43	1.49
26	1.20	1.30	....	1.75	2.6	1.37	1.57	1.57
27	1.21	1.30	....	1.81	2.9	1.39	1.63	1.49
28	1.50	1.32	....	1.90	2.45	1.52	1.62	1.42
29	1.91	1.45	....	2.37	2.15	1.60	1.82	1.34
30	2.03	1.64	....	3.0	1.90	1.72	1.85	1.29
31	1.96	....	....	2.75	....	1.80	....	1.22

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1919.												
1	1.20	0.80	0.50	0.68	1.39	1.23	1.07	0.96	1.50	1.63	1.33	....
2	1.36	.77	.49	.71	1.33	1.26	1.04	.94	1.45	2.05	1.32	....
3	1.37	.75	.48	.74	1.28	1.25	1.04	.92	1.37	2.86	1.33	....
4	1.33	.73	.45	.73	1.23	1.22	1.07	.91	1.30	3.18	1.28	....
5	1.38	.70	.43	.78	1.21	1.20	1.07	.92	1.24	....	1.28	....
6	1.67	.68	.45	.81	1.21	1.18	1.09	.92	1.16	....	1.23	....
7	1.90	.67	.45	.81	1.22	1.16	1.13	.80	1.12	....	1.18	....
8	1.95	.65	.46	.81	1.23	1.14	1.13	.85	1.08	....	1.05	....
9	1.91	.65	.52	.81	1.26	1.12	1.14	.98	1.25	2.50	1.13	....
10	1.80	.67	.49	.80	....	1.12	1.17	1.00	1.40	2.28	1.11	....
11	1.71	.65	.47	.80	....	1.11	1.27	1.00	1.32	2.02	1.04	....
12	1.60	.63	.50	.81	....	1.11	1.28	.98	1.45	1.38	1.01	....
13	1.50	.61	.45	.81	1.21	1.10	1.34	1.08	2.75	1.69	1.09	....
14	1.45	.62	.43	.81	1.23	1.10	1.39	1.18	2.98	1.61	1.06	....
15	1.37	.62	.40	.80	1.29	1.11	1.38	1.16	2.52	1.54	1.11	....
16	1.29	.60	.40	.79	1.33	1.10	1.36	1.26	2.23	1.46	1.11	....
17	1.23	.57	.40	.81	1.31	1.10	1.33	1.23	2.15	1.40	1.24	....
18	1.16	.70	.39	.83	1.30	1.10	1.31	1.22	2.35	1.38	1.47	1.44
19	1.10	.75	.38	.88	1.35	1.10	1.28	1.43	2.15	1.37	1.60	1.39
20	1.05	.69	.42	.90	1.50	1.11	1.26	1.50	1.95	1.57	1.72	1.36
21	1.05	.66	.50	.92	1.50	1.13	1.26	1.46	2.35	1.71	1.70	1.36
22	1.03	.64	.46	.92	1.48	1.13	1.25	1.40	2.15	1.73	1.65	1.41
23	.98	.63	.45	.94	1.44	1.15	1.21	1.33	2.10	1.58	1.88	1.43
24	.95	.60	.44	.94	1.41	1.15	1.19	1.27	2.50	1.46	....	1.58
25	.94	1.44	.42	1.19	1.44	1.15	1.14	1.20	2.70	1.43	....	1.66
26	.87	.55	.40	1.37	1.42	1.13	....	1.16	2.35	1.32	....	1.81
27	.90	.53	.39	1.55	1.38	1.12	....	1.18	2.08	1.29	....	1.78
28	.88	.52	.38	1.54	1.34	1.11	....	1.25	1.96	1.27	....	1.69
29	.87	....	.41	1.49	1.32	1.11	....	1.36	1.88	1.24	....	1.61
30	.85	....	.46	1.44	1.26	1.09	....	1.50	1.70	1.44	....	1.51
31	.82	....	.61	....	1.22	....	.97	1.55	....	1.35	....	1.61

MISCELLANEOUS MEASUREMENTS.

Miscellaneous discharge measurements in southeastern Alaska in 1919.

Date.	Stream.	Tributary to—	Locality.	Discharge.
				Sec.-ft.
Apr. 11	Spruce Creek	Windham Bay	Mouth of creek	15.6
July 12	do	do	At bridge near mill of Alaska Peerless Gold Mining Co., half a mile above mouth of creek.	28.6

WATER POWER ON CERTAIN STREAMS IN SOUTHEASTERN ALASKA.

Owing to the great variation in flow of streams in southeastern Alaska, storage is an important factor in determining the power that can be developed and the cost of development. The amount of possible storage is generally estimated, because few local maps or sketches of river basins are available.

In the following table the estimates of annual flow at gaging stations are based on records prior to October 1, 1918. The flow at the point of diversion to the power plant is estimated from the records for gaging stations, by comparison with records for other streams, or from precipitation data. The "annual flow" is that for the climatic year ending September 30. The effective head is the elevation of the lake or dam site above high tide plus two-thirds of the head created by the dam minus 10 feet (elevation of nozzles of impulse turbines). The estimates of available power are based on continuous and complete utilization of a plant having an efficiency of 80 per cent.

The following abbreviations are used in the table:

A. B. S., Alaskan Boundary Survey maps.
U. S. G. S., U. S. Geological Survey topographic maps.
U. S. F. S., U. S. Forest Service topographic maps.
U. S. F. S. R., U. S. Forest Service timber reconnaissance maps.

Data concerning certain streams in southeastern Alaska on which power may be developed.

Stream and location.	Drainage area.	Map used.	Records available.	Mean annual flow.		Elevation of lake or dam site above high tide.	Storage required to equalize flow, or storage available.	Area of lake or basin.	Height of dam above or depth of tunnel below lake surface for obtaining required storage.	Length of conduit.	Mean static head.	Continuous horsepower at 80 per cent efficiency.
				At gaging station.	At point of diversion.							
	Square miles.			*Sec.-ft.*	*Sec.-ft.*	*Feet.*	*Acre-feet.*	*Acres.*	*Feet.*	*Miles.*	*Feet.*	
Mainland:												
Endicott River on west shore of Lynn Canal (reconnaissance by Alaska Gastineau Mining Co., 1913; lake gone).			None			175	53,000 (50-foot dam 18 miles from beach).		250-foot dam for head only.		(a)	10,000
Small stream on west shore of Taiya Inlet; mouth of Skagway.	1.8	A. B. S.	do.		11	3,000				1.75	3,000	3,000
Sherman Creek at Comet; on east side of Lynn Canal.	3.65	U. S. G. S.	September, 1914, to December, 1917.	31	34 (storage for only 7 sec.-ft.)	500	2,000		100	1	560	350
Davies Creek, Berners Bay.	16.0	U. S. G. S.	Measurement, Sept. 8, 1916.		145	200	40,000		150	1.7	290	4,000
Peterson Lake outlet near Eagle River Landing.	5.7	U. S. G. S.	None		40	650	10,000	85	50	(b)	675	3,000
Montana Creek at elevation 250 feet; tributary to Mendenhall River; power house at elevation 50 feet.	10.9	U. S. G. S.	do.		110	250	30,000		150	3	300	3,000
Nugget Creek, Mendenhall Glacier.												[c]3,500
Salmon Creek near Juneau.	[d]5.34											[c]6,000
Gold Creek at Juneau	[d]9.47											[c]1,000
Sheep Creek at Thane	[d]4.57		July 26, 1916	52	41 (storage for only 30 sec.-ft.).	640	7,000	150 (at 710-foot contour).	70		680	2,000
Grindstone Creek at Taku Inlet.	[d]3.6		May 6, 1911	41	32 (storage for about 20 sec.-ft.).	220						
Carlson Creek at Taku Inlet.	[d]22.3		July 18, 1916	358	283 (storage for only 100 sec.-ft.).	350	20,000	300 (at 470-foot contour).			420	3,800
Annex Creek at Taku Inlet.	[a]6.4											[b]5,000

Norris Creek at Norris Glacier.	9.0	A. B. S.	None.		100	[e]350				2.5	400	3,600
Turner Lake Outlet, Taku Inlet.	66	A. B. S.	May, 1908, to April, 1909.	450	550	80	180,000	2,400	75	6	130	6,500
Carlson Lake outlet at Taku Harbor.			Measurement, Sept. 3, 1916.		8.6	[e]1,100			25			850
Crater Lake outlet at Port Snettisham.	11.9	A. B. S.	Jan. 23, 1913.	197	190	[f]1,012	54,000	700	Dam, 50; tunnel, 50.	.9	1,012	17,500
Long Lake outlet at Speel River.	33.2	A. B. S.	do.	75	465	[f]803	151,000	2,000	Dam, 50; tunnel, 35.		[g]515	22,000
Speel River at Port Snettisham.			July 15, 1916, to Sept. 30, 1918.	2,700	2,700 (storage for only 1,875 sec.-ft.).	[f]150	370,000 (above elev. 192 feet).		157		262	45,000
Tease Lake outlet at Port Snettisham.	10.3	A. B. S.			125	[f]1,010	35,000	240	Dam, 50; tunnel, 100.	1.1	1,000	11,500
Sweetheart Falls Creek at Port Snettisham.	27	A. B. S.	July 31, 1915, to Mar. 31, 1917; May 21, 1918.	319	325	[e]520	90,000	1,500	50	2	545	15,000
Stream entering salt lake at head of Hobart Bay.	40	A. B. S.	None.		Storage for only 160 second-feet.	250	45,000 (between 300 and 400 foot contours).		150	2	360	5,000
Below fork of stream entering head of Port Houghton.	73	A. B. S.	do.		Storage for only 300 second-feet.	50	50,000 at lake; 50,000 (between 100 and 200 foot contours).	440	Lower dam, 150 feet; dam at lake or storage only 50 feet.	125	165	5,400
Farragut River tributary to Farragut Bay; dam at lake on north fork, 12 miles from beach.			do.		Storage for only 125 second-feet.	250		500	100	12	[h]267	5,200
Cascade Creek, Thomas Bay.	21	A. B. S.	Oct. 27, 1917.	304	At dam site, 220 (storage for only 80 sec.-ft.).		10,500		150	1.95	1,690	12,300
Stream tributary to west shore of Thomas Bay; 1.4 miles north of West Point.	10	A. B. S.	Measurement, Aug. 9, 1917.		50	[e]400	14,000	300	40	1.25	416	1,900
Stream tributary to north shore of Bradfield Canal, 2 miles east of Blake Channel.	15.5	A. B. S.	None.		90	[i]150				2	[a]175	1,400

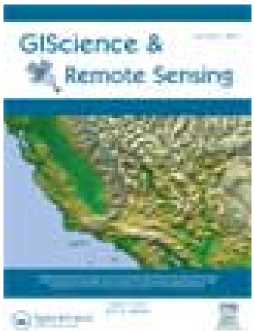
[a] Elevation of power house, 95 feet.
[b] Three miles to Pearl Harbor; 4,000 feet of tunnel and 1,500 feet of pipe line to Tee Harbor.
[c] Developed.
[d] Determined by Alaska Gastineau Mining Co.
[e] Elevation determined by aneroid barometer.
[f] Reported by Speel River Project (Inc.).
[g] Elevation of power house, 300 feet.
[h] Elevation of power house, 50 feet.
[i] Estimated.

Data concerning certain streams in southeastern Alaska on which power may be developed—Continued.

Stream and location.	Drainage area.	Map used.	Records available.	Mean annual flow. At gaging station.	Mean annual flow. At point of diversion.	Elevation of lake or dam site above high tide.	Storage required to equalize flow, or storage available.	Area of lake or basin.	Height of dam above or depth of tunnel below lake surface for obtaining required storage.	Length of conduit.	Mean static head.	Continuous horsepower at 80 per cent efficiency.
	Square miles.			*Sec.-ft.*	*Sec.-ft.*	*Feet.*	*Acre-feet.*	*Acres.*	*Feet.*	*Miles.*	*Feet.*	
Mainland—Continued.												
Stream tributary to north shore of Bradfield Canal, 11 miles east of Blake Channel; three-fourths mile from beach.	80	A. B. S.	None		700	a50	200,000 (between 100 and 200 foot contours; estimated).	3,000 (at 250 foot contour).	150	4.5	165	10,000
Stream tributary to north shore of Bradfield Canal, 1 mile west of the head; 1 mile from beach.	42	A. B. S.	do		300	a75	80,000 (between 150 and 250 foot contours).	1,100 (at 250 foot contour).	175	.75	200	5,500
Stream tributary to south shore of Bradfield Canal, 1 mile west of the head.	14	A. B. S.	do		100	1,100	25,000	500	Dam, 25; tunnel, 25.	2	1,100	10,000
Stream tributary to south shore of Bradfield Canal, 11 miles east of Blake Channel; at lake 5 miles from beach.	36	A. B. S.	do		Storage for 250 second-feet.	a300	65,000	300	130	5	376	8,500
Stream entering south shore of Bradfield Canal, 2 miles east of entrance.	27	A. B. S.	do		150	a150	39,000		100	2	210	3,800
Stream tributary to east bank of Chickamin River, 4 miles upstream from mouth.	23	A. B. S.	do			a150				.5		
Shelockum Lake outlet, Bailey Bay.	18	A. B. S.	June 4, 1915	211	200	344	52,000	350	Dam, 60; tunnel, 100.		340	6,000
Revillagigedo Island:												
Orchard Lake outlet, Shrimp Bay.		U. S. F. S.	May 28, 1915	600	600	134	130,000	1,400	70		175	9,500
Mahoney Creek, George Inlet.		U.S.F.S.R.	Measurement, Sept. 13, 1917		At lake, 35; at beach, 58.	2,000	7,000	180	Tunnel, 60	.75	b1,890	6,000
Beaver Falls Creek, George Inlet, at Upper Lake outlet.	3.6		Three measurements in 1917.		55	1,100		234	Dam, 25; tunnel, 25.	2.1	1,100	5,500
Beaver Falls Creek, George Inlet, at Lower Lake outlet.	4.9	U. S. F. S.			75	792	10,000	62				

Swan Lake outlet, Carroll Inlet.			Aug. 24, 1916	440	435	[c]225	75,000	300[a]	150	1.25	3.5	12,000
Fish Creek near Sealevel mine.		U.S.F.S.R.	May 19, 1915	429	400	[c]275	66,000	1,700	35	1.5	290	10,500
Annette Island:												
Tamgas Lake	5.9	Chart	None		60	[a]150			50			1,000
Chester Lake	6.0	do	do		60	825	10,000	64	Dam, 50; tunnel, 100.		815	4,500
Deep Lake	10	do	do		100	[a]150						2,000
Millanson Lake	6.1	do										1,500
Admiralty Island:												
Hasselborg Lake outlet, entering Mitchell Bay, Kootznahoo Inlet.	[d]90		None		800	247		3,500[d]	60	6-7	247	18,000
Chichagof Island:												
Porcupine Creek near Nickel; west coast.												5,000
Falls Creek near Nickel; west coast.												3,000
Baranof Island:												
Green Lake outlet at Silver Bay.			Aug. 22, 1915	30.6	270 (storage for 210 sec.-ft.).	[a]240	42,	175[a]	165	0.4	340	6,500
Barnanof Lake outlet, Warm Spring Bay.		U. S. F. S.	June 28, 1915	411	365	134	90,000	700	100	.3	200	6,500
Second Lake on large stream at head of Cascade Bay.			Measurement, Aug. 14, 1917		420	[a]185	100,000		Dam, 50; tunnel, 50.		190	7,000
Patterson Bay near south entrance.			Measurement, Aug. 15, 1917.		60	[a]350	18,000	600[a]	Dam, 25; tunnel, 15.	.2	360	2,000
Small stream 500 feet south of entrance to Patterson Bay.			do		35							1,000
Stream at head of west arm of Patterson Bay.			Measurement, Aug. 16, 1917.			[a]120			40	.06	145	850
Big Port Walter	3.7	U. S. F. S.	Measurement, Aug. 17, 1917.	30	480	9,000	9,000	365	Dam, 10; tunnel, 25.	.08	460	1,200
Kosciusko Island: Stream entering Davison Inlet.	3.6	Chart		30	520[a]	6,000	6,000		do	1	510	1,400
Prince of Wales Island:												
Karta River, Karta Bay	49.5	U.S.F.S.R.	July, 1915	493	465	104	90,000	1,600[a]	50	.8	137	5,800
Myrtle Creek at Niblack Lake outlet.			July 30, 1917	92	53	450	10,000	383	Tunnel, 40		427	2,000
Myrtle Creek at Myrtle Lake outlet.					80	95	15,000	122	Dam, 20; tunnel, 10.		105	750
Reynolds Creek at Coppermount.	5.05	U. S. G. S.	Measurement, Sept. 14, 1915.		64	876	12,000	185	Dam, 15; tunnel, 60.	1	856	5,000
Mill Creek near Wrangell	50	Chart	June 17, 1915, to Sept. 30, 1917.	412	440	[c]100	112,000	500	125	1	166	6,500
Douglas Island:												
Treadwell mine ditch												[e]4,000

[a] Estimated. [b] Elevation of powerhouse, 80 feet. [c] Elevation determined by aneroid barometer. [d] Reported by Treadwell Mining Co. [e] Developed.



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Monitoring Large Woody Debris Dynamics in the Unuk River, Alaska Using Digital Aerial Photography

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Monitoring Large Woody Debris Dynamics in the Unuk River, Alaska Using Digital Aerial Photography

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Abstract: Large Woody Debris (LWD) and changes in its accumulation pattern influence the morphology, flow characteristics, ecological attributes, and physical habitats along a river. Digital aerial photos were acquired for the Unuk River in Alaska during the spring of 2003 and 2004. Digital processing of aerial photos involved high-pass filtering on the second principal component image, followed by a low-pass filtering, thresholding, and color coding to map individual logs and large wood accumulations. This processing technique provided an effective classification of the LWD with an overall classification accuracy of 89%. In the selected test site, the 2004 images show a 23% decrease in LWD, which is attributed to the large-scale wash-over of the wood due to a known flooding event in October 2003. Large shifts in LWD have caused main channel shifts, channel splits, merging of split channels, and changes in locations of sand bars and pools, dislocating and redistributing known fish habitat.

BACKGROUND

Large woody debris (LWD) refers to wood pieces (i.e., entire fallen trees, branches, rootwads) typically larger than 10 cm in diameter and 2 m in length within stream and river ecosystems (Bilby and Ward, 1989; Maser and Sedell, 1994). The quantity and distribution of LWD within a river network when spatially mapped over the landscape presents large wood patterns that are inherently related to within-watershed processes. These relationships between LWD and a river's geomorphological, hydrological, and ecological processes have been widely documented. Research studies have recognized the importance of LWD within rivers and its influence in creating pools (Keller and Swanson, 1979, Robison and Beschta, 1990), modifying sediment storage (Megahan and Nowlin, 1976; Naiman and Sedell, 1979), promoting channel complexity (Keller and Swanson, 1979; Abbe and Montgomery, 1996), providing fish and macroinvertebrate habitat (Anderson and Sedell, 1979; Bisson et al.,

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1987), and altering channel hydraulics/bar accretion (Zimmerman et al., 1967; Bilby, 1984; Abbe and Montgomery, 1996). The ability to document and understand LWD distribution patterns creates the link in further understanding the variations in stream processes and form within a watershed (Piegay and Marston, 1998; Marcus et al., 2002).

LWD distributions vary according to stream size and location within the watershed (Martin and Benda, 2001; Gurnell et al., 2002; Marcus et al., 2002). To date the majority of LWD studies have primarily focused on smaller stream networks with only a few studies on larger river systems (Abbe and Montgomery, 1996; Piegay 2003). Regardless of the stream size, these studies have commonly involved an intense field component incorporating comprehensive ground measurements. However, in larger river systems on-site sampling is often difficult given their size and typically complex habitat. Due to time and logistical constraints (especially in remote locations) and the fact that these areas lack an easily repeatable temporal component, comprehensive ground surveys are essentially not practical as effective survey methods (Poole et al., 1997; Legleiter et al., 2002; Leckie et al., 2005). For these reasons, large rivers require alternative methods in order to examine and spatially document LWD. The ability to spatially and temporally monitor LWD dynamics within large rivers systems will assist in better understanding the variation in stream processes and associated aquatic habitat.

Remote sensing offers an alternative method to researchers and is increasingly being used for riverine landscape applications (Mertes, 2002). Airborne remote sensing allows the acquisition of high spatial resolution imagery covering an entire river's length. However, the application of digital image processing techniques to analyze remote sensing data for LWD mapping within a river system is a field that is still in its infancy (Marcus et al. 2002; Leckie et al. 2005).

Marcus et al. (2002) examined the use of supervised classification on 1 m spatial resolution, 4-band imagery for LWD mapping with limited success due to the overlapping spectral signatures of the LWD and gravel. They attributed these poor results to insufficient spatial resolution of the imagery, mixed pixel effects, and also to problems with coregistration of the imagery with the field maps. The problem with coregistering the images with field maps was also noted by Wright et al. (2000), specifically in matching small features (e.g., individual logs) to the imagery. This misalignment in the imagery and field maps subsequently created a misclassification when using the field maps as training data in the supervised classification. Marcus et al. (2003) obtained successful results in mapping woody debris using high spatial resolution (1 m) hyperspectral (HSRH) imagery by applying a variance-based principal component transformation to the HSRH images, followed by a matched-filter approach available in ENVI™ software package. They concluded that the hyperspectral imagery provides great potential in spatially mapping woody debris at the watershed scale. Leckie et al. (2005) also obtained good classification results of large woody debris using 0.80 m, 8-band CASI imagery. They used a spectral-angle mapper approach to achieve a classification accuracy of 79%. Both Marcus et al. (2003) and Leckie et al. (2005) encountered problems in mapping LWD when the wood was in the shadow cast or obstructed by water and vegetation and concluded that these obstructions are a major limitation in stream mapping. Leckie et al. (2005) determined that it is desirable to use sensors that acquire at least four bands (blue, green,

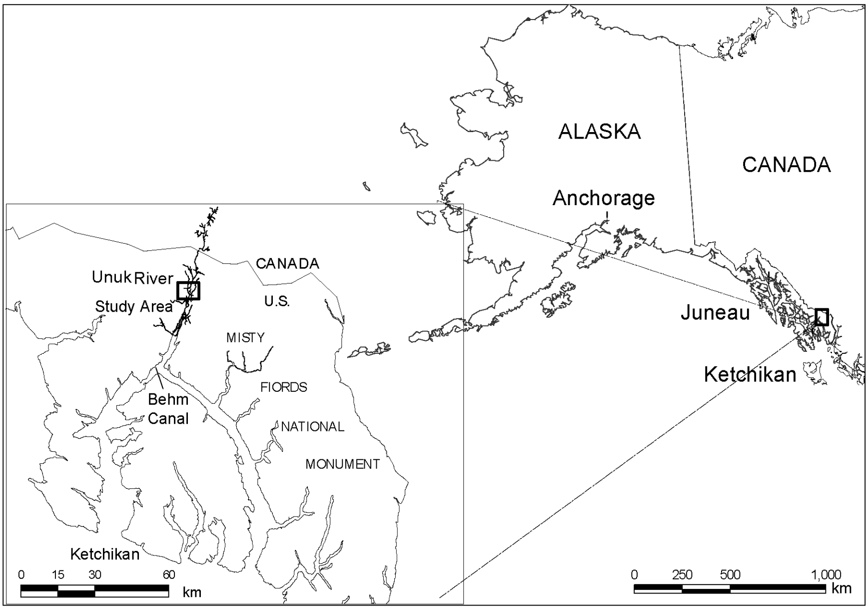

Fig. 1. Location of study area. The Unuk River originates in British Columbia with its saltwater confluence in southeastern Alaska, northeast of the city of Ketchikan. The area for detail study is located approximately 12 km south of the U.S.–Canada border.

red, and near-infrared) for mapping stream features. Hyperspectral data, however, is relatively expensive to acquire on a routine basis for monitoring.

The research reported in this paper is unique in that it examines the potential for using relatively low cost, high-resolution (80 cm and 60 cm), 3-band aerial photography to spatially and temporally map LWD on the floodplain of a glacial, transboundary river. Digital detection of LWD is based on its spatial and textural characteristics rather than its spectral response alone. Additionally, this study evaluates LWD over a two-year time frame within the study area, allowing for change detection.

STUDY AREA

The Unuk River (Latitude 56º14’ N, Longitude 130º52’ W) is 129 km long and drains an area of 3,885 km^2 (Fig. 1). The study area focuses on a 0.32 km^2 stretch of the river approximately 23 km upstream from the saltwater confluence. The Unuk River emerges from a heavily glaciated area of northern British Columbia and flows into Burroughs Bay in upper Behm Canal, 85 km northeast of Ketchikan, Alaska. The lower 39 km of the river is in Alaska and lies within the Misty Fiords National Monument portion of the Tongass National Forest. Misty Fiords is part of the Rounded Moutain ecological subsection within southeast Alaska and is underlain by a granitic batholith. Volcanic activity has occurred at Blue Lake within the Unuk River watershed as a result of bedrock folding and faulting from the abutment of the Coast Range megalineament (Nowacki et al., 2001).

The United States Geological Survey (USGS) installed a stream gage in May of 2003, and records show a mean discharge of 229.62 m^3/s, with a minimum of 37.60 m^3/s and a maximum of 984.18 m^3/s. Peak flow events typically occur during summer snowmelt and with the heavy rains normally occurring in late fall. Annual precipitation for the area averages approximately 4 meters, which includes snowfall. The Unuk River channels (Alaskan portion) can be characterized as large braided, glacial outwash channels and function as sediment deposition areas. These channels transport extremely large sediment loads that create the braided channel network and extensive flood plain (Paustian et al., 1992). The Unuk River's forest and riparian cover consists of Sitka spruce (*Picea stichensis*), western hemlock (*Tsuga heterophylla*), black cottonwood (*Populus trichocarpa*), and red alder (*Alnus rubra)* comprising the overstory, with Sitka alder (*Alnus sinuate*), willow (*Salix spp*.), blueberry and huckleberry (*Vaccinium spp*.), salmonberry (*Rubus spp.)*, and false azalea (*Menzizia spp*.) inhabiting the understory. Field data collected in 2003 and 2004 show that individual logs from these tree species range approximately from 25 cm to 150 cm diameter. Accumulations of LWD of interest for fish habitat generally occupy much larger areas than these values, making the airborne datasets of less than 1 m spatial resolution suitable for LWD mapping purposes.

METHODS

Data Input

Airborne digital images were acquired for the study area on May 5 in both 2003 and 2004 with flow conditions of ~84.95 m^3/s and 195.24 m^3/s, respectively. Flights were scheduled to correspond with low-flow events in the spring (shortly after ice-out, but before deciduous leafout) to facilitate a more comprehensive view of the river channels. Flight height was set at 1,981 meters in 2003 with a corresponding spatial resolution of 80 cm. In 2004 the flying height was lowered to 1,280 meters to acquire images at a higher spatial resolution of 60 cm. The aircraft used was a DeHavilland Beaver with a fixed-belly mount that housed the digital camera. The camera operated in the blue, green, and red spectral regions of the electromagnetic spectrum. Additional hardware included an on-board avionics quality GPS receiver, digital compass, inertia measurement unit (IMU), and on-board data logging system (TerraMar, 2005). Images were acquired with a 20% endlap and sidelap.

The Alaska Department of Fish and Game used TerraMar™ 2005, a commercially available software package, to carry out standard preprocessing of the digital images and to provide the researchers with a georeferenced mosaic of the study area. Field data was collected in spring 2003 and spring 2004 concurrent to the flight overpass. Locations of ground control points were recorded for pre-processing of remotely sensed images. Detailed ground validation of remote sensing observations using global positioning system (GPS) measurements and field photos was accomplished. Individual tree species were identified and documented and locations and dimensions of LWD were measured.

Image Processing

In this study, the input data were limited to the visible part of the spectrum, where the woody debris does not show a unique spectral signature. Even when more spectral bands are available, such as with hyperspectral data, it would be difficult to uniquely map LWD due to overlap of spectral signature of wood with the spectral signature of sand and gravel that surrounds and partly covers it (Marcus et al., 2003). An alternate technique was required for digital detection of LWD. As our interest was limited to the LWD within the stream, all non-stream areas were masked out *a priori*. Further processing steps adopted in this study are shown in Figure 2.

This processing scheme was based on highlighting the spatial and textural characteristics of the LWD instead of classifying the LWD based on its spectral characteristic alone. Enhancements in the spatial domain required the use of only one spectral band. A principal component transform was performed on the three highly correlated bands (Fig. 2A) to reduce the dimensionality of the data (Faust, 1989; Jensen, 2005). Visual analysis of the three principal components showed that the LWD was pronounced in the second principal component image (PC2) (Fig. 2B), which was then used as the base image for further processing. On this image the LWD shows an abrupt change in digital values compared to the background sand and gravel (high-frequency variations). To enhance these high-frequency variations the PC2 image was filtered using a 3 × 3 variance filter kernel. This filtering operation is best represented by the following formula (Leica Geosystems, 2003):

$$\text{Variance} = \frac{\sum(\rho_{i,j}, M)^2}{n-1},$$

where $\rho_{i,j}$ = the pixel value at location (i,j) in the filter window; M = the mean pixel value; and n = the number of pixels in the filter window. The resultant image has a textural enhancement such that LWD stands out quite prominently (Fig. 2C). However, other high-frequency variations (noise) not related to LWD also gets highlighted, imparting a salt/pepper effect in the non-LWD areas. To suppress this noise and to further isolate the large wood, a 7 × 7 low-pass filter was successfully applied (Fig. 2D).

The high contrast between the LWD and background areas allowed for an easy thresholding to discriminate wood and no-wood areas, which were assigned digital values 1 and 0, respectively (Fig. 2E). The threshold value was set where the slope of the image histogram abruptly changed. To further highlight and map the LWD, areas with digital value of one were color coded and displayed on the original aerial photo (Fig. 2F).

Accuracy assessment of the LWD classification was addressed using two approaches. The first method compared field-collected data with the LWD classification. In the field, areas (polygons) of wood and no-wood areas were mapped, which served as a reference data set for accuracy assessment. However, due to an insufficient number of mapped polygons, a second approach for accuracy assessment was also used. In the second approach an equalized random selection of reference locations for the LWD class and the no-LWD class were generated. A sample size of 100

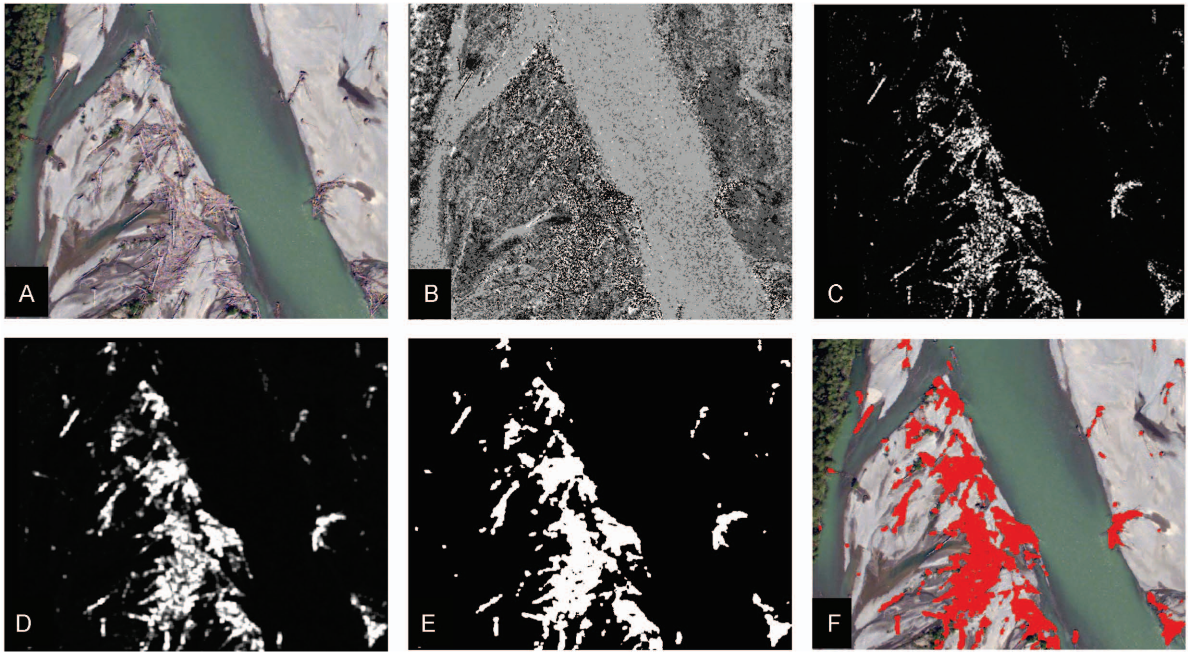

Fig. 2. Processing chain for digital detection of LWD. A through F depict the successive steps followed to detect and map LWD. (A) shows the original 3-band RGB image, (B) is the second PC band for the original RGB composite, (C) is the result of a 3 × 3 variance filter on the PC2 image, (D) is the product after a subsequent 7 × 7 low-pass filtering to remove noise, (E) is a 2-bit map generated by thresholding and assigning DN one to LWD and zero to background, and (F) is the final LWD map.

Table 1. Accuracy Assessment of the LWD Classification

Class	Ground reference		
	No-LWD	LWD	Total
No LWD	96	4	100
LWD	18	82	100
Total	114	86	200
User's Accuracy, pct.	96.0	82.0	
Producer's Accuracy, pct.	84.2	95.4	
Overall User's Accuracy, pct.		89.0	

reference points per class was used in this analysis to obtain an unbiased, representative sample (Congalton and Green, 1999). An accuracy assessment cell array (error matrix) was created to compare the classified image with reference data. This error matrix contained the class name (LWD and no-LWD) for the pixels in the classified image file and the class name for the corresponding reference pixels. The class name for the reference pixels used to populate the error matrix was assigned by visual interpretation of the original aerial photographs.

RESULTS AND DISCUSSION

LWD Detection and Mapping

The processing technique used in this study provided an effective enhancement of the LWD at a level of detail from single logs to LWD accumulations (Fig. 3). The ground-collected data of the LWD occurrence and distribution corroborates well with results obtained from the image processing with an overall accuracy of 100%. This high classification accuracy is largely misleading due to the small sample size of the field-collected data (n = 10, 5 locations = LWD, 5 locations = no-LWD). Other samples were collected, but were excluded from the error matrix because of the geographical uncertainty (GPS accuracy ±5 m) when overlaid on the high spatial resolution imagery (60 and 80 cm). This positional uncertainty mainly applied to field data that documented single logs within the study area versus the LWD accumulations. For this reason, the reference data included in the error matrix above reflects only LWD accumulations and is biased toward LWD accumulations, and not a truly representative assessment of the LWD classification.

As stated above, in order to obtain an unbiased and representative accuracy assessment of the LWD classification, a second error matrix was generated using the original imagery as the reference data. The second assessment resulted in an overall classification accuracy of 89% (Producer's Accuracy = 95.4%, User's Accuracy = 82.0 %, and Overall Kappa = 0.78). This high accuracy in part could be attributed to the larger size of the LWD within the study area and the high spatial resolution of the imagery. Another factor contributing to the success of the LWD classification is the

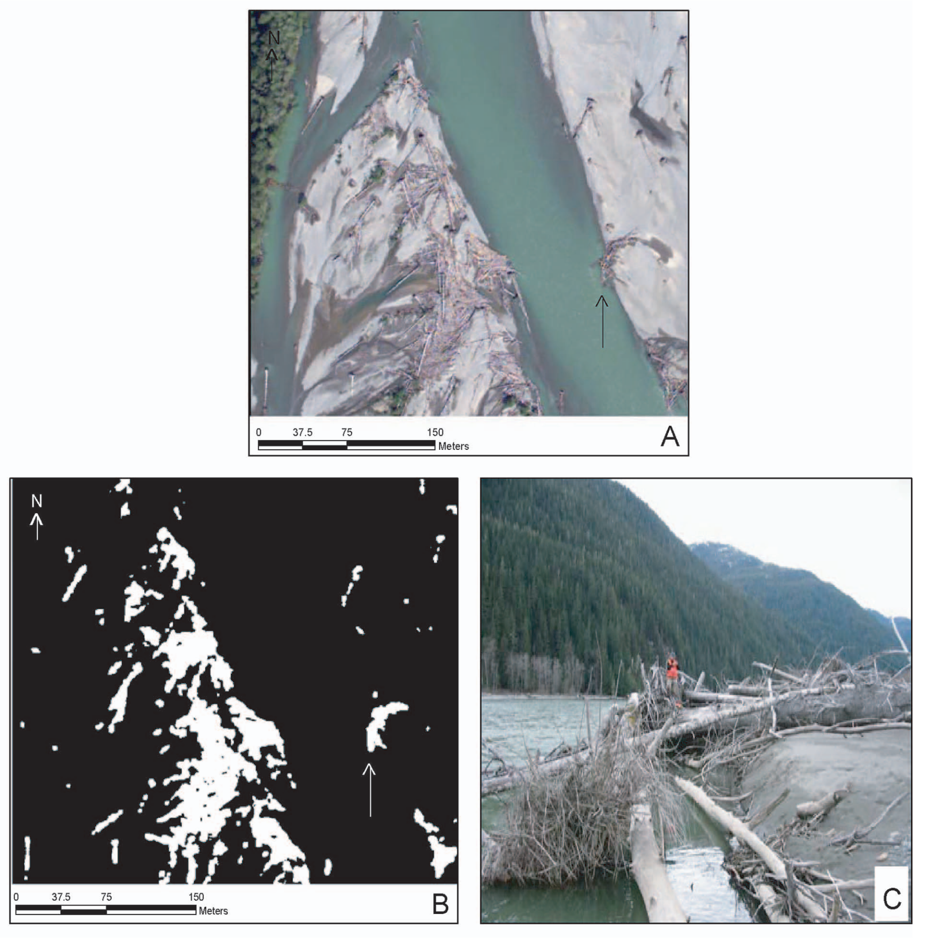

Fig. 3. Field validation of remote sensing observations. Arrows in (A) and (B) point to the location where field photo (C) was taken. LWD consists of of Sitka spruce, black cottonwood, and alder.

accommodating morphology of the study area, in that it is a wide, mostly sparsely vegetated floodplain expanse.

The remote sensing method, however, does have its limitations in that it did not always detect LWD in areas where the wood was obstructed by overhanging bank vegetation or shadows. Also some areas of the river were falsely enhanced where there was an overlying sun glare, combined with surface water roughness. These problems are inherent in the dataset due to constraints of the weather and image acquisition, and are difficult to isolate using the available dataset alone. Use of simultaneously acquired high-resolution thermal infrared images may in part provide a solution to this problem. The processing scheme followed in the study is successful in identifying LWD even in areas where unsupervised and supervised classification would not succeed due to mixed spectral response of wood, sand, and gravel.

Change Detection and Implications

A second objective of this study was to investigate the temporal changes in LWD distribution. LWD maps generated using the above method were integrated and analyzed in a geographic information system (GIS) framework to assess the changes that occurred between spring 2003 and spring 2004, which were then validated by field checks. Quantitative change detection was carried out by computing the areas of LWD classified on the respective images and then subtracting these values to quantify the change. In the second attempt to monitor the changes, classified LWD areas on the two date images were overlaid in a GIS environment. Channel boundaries were also digitized and overlaid. Channel shift changes and redistribution of LWD were visually analyzed.

Image processing of the study area datasets reveal that during 2003, there was approximately 36,628 m^2 of LWD composed of both scattered pieces and small/large accumulations. However, in 2004, within the same area there was approximately 28,046 m^2 of LWD. This represents an approximately 23% decrease in LWD within the 0.32 km^2 test site. This decrease in LWD can be directly linked to a high-flow event recorded by the USGS gage (984.18 m^3/s) on October 26, 2003.

Besides the reduction in the amount of LWD, image processing results showed large shifts in the LWD distribution pattern. These shifts directly influence the channel morphology and therefore are largely responsible for observed significant river channel migrations and transformations (Fig. 4). Figure 4A shows the location of the channel and associated LWD (red areas) in spring 2003. Figure 4B shows the location of the same channel and associated LWD (green areas) in spring 2004. A comparative analysis of these images shows several interesting changes (Fig. 4C). From 2003 to 2004 the main channel appears to be in general slightly wider. This could be partly caused by higher discharge in spring 2004 due to increased snow/glacier melt and partly due to the October 2003 flood event, which cleared some LWD constricting the 2003 flow. Close to location "X" in Figure 4, a large accumulation of LWD in 2003 was transported away during the October 2003 flood, causing channel avulsion and the appearance of a new subsidiary channel that can be seen in the 2004 image. At another location "Y," the LWD accumulation at the tip of a mid-channel bar in 2003 (which probably caused the formation of this bar) was similarly removed and redistributed. This resulted in increased flow at this point, a complete disappearance of the mid-channel bar, and a merging of the original split channel into one main channel.

Such large-scale shifts in the LWD distribution pattern and the associated channel dynamics, as exemplified in Figure 4, directly impact navigation and aquatic habitat within these river systems. In a glacial, gravel-bed river such as the Unuk River, LWD distributional patterns and form provide critical habitat to juvenile salmonids (Fig. 5A). LWD within the active river flow form channel obstructions concentrating turbulent flows and forcing channel bed scour and pool formation (Fig. 5B). Abbe and Montgomery (1996) found that 70% of all observed pools within the Queets River floodplain were associated with large wood and were usually deeper with varying depths compared to free-formed pools. These pools are essential to juvenile salmon, providing refugia from high flow velocities; additionally the LWD provides

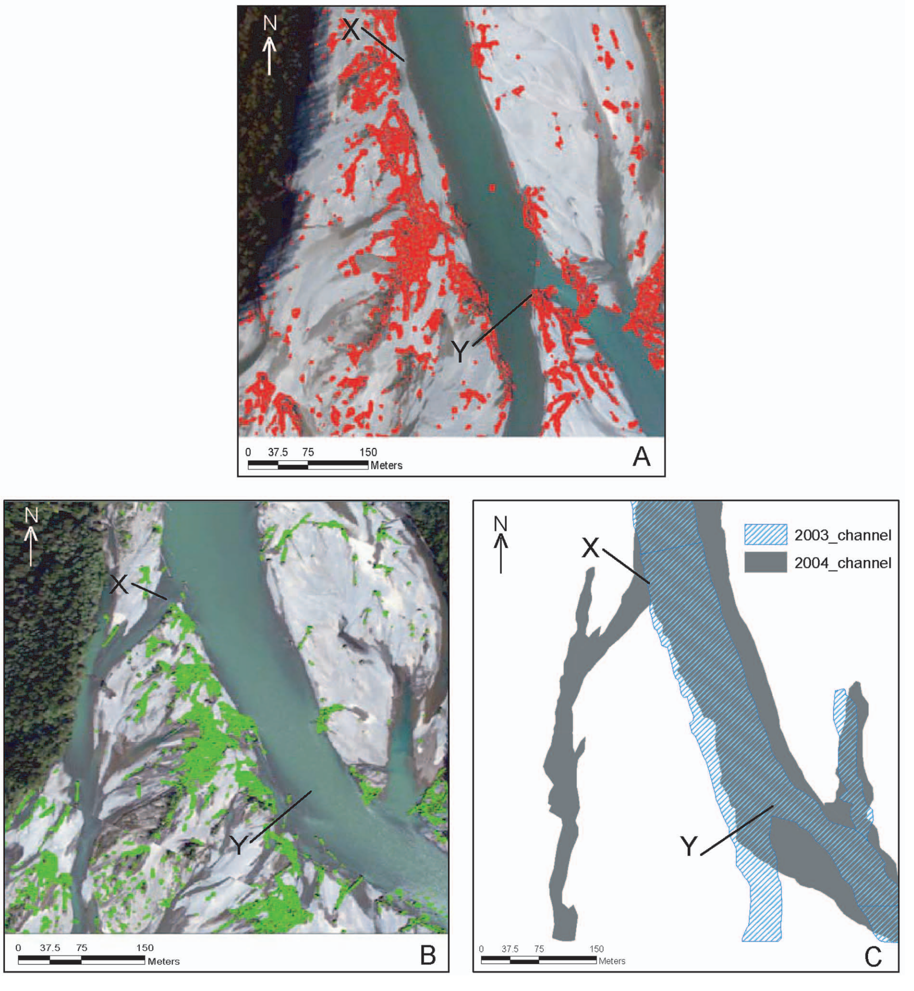

Fig. 4. Temporal changes in LWD distribution and associated changes in the channel. (A) shows in red LWD mapped from spring 2003 image; (B) shows in green LWD mapped from spring 2004 image; (C) shows a migration of the main channel to the right, the combining of split channels due to dislocation of LWD in the mid-channel bar, and creation of a new channel due to redistribution of LWD.

cover and indirectly a source of food items (Naiman and Bilby, 1989). Therefore, the quantity and spatial distribution of LWD largely controls the location and amount of fish habitat within the Unuk River.

CONCLUSIONS AND RECOMMENDATIONS

The ability to spatially map LWD within a river system is a valuable resource management tool for biologists. A large, glacial river like the Unuk does not lend itself to traditional (foot) habitat surveys and requires alternative methods to monitor large LWD distribution patterns. High-resolution airborne photography using digital

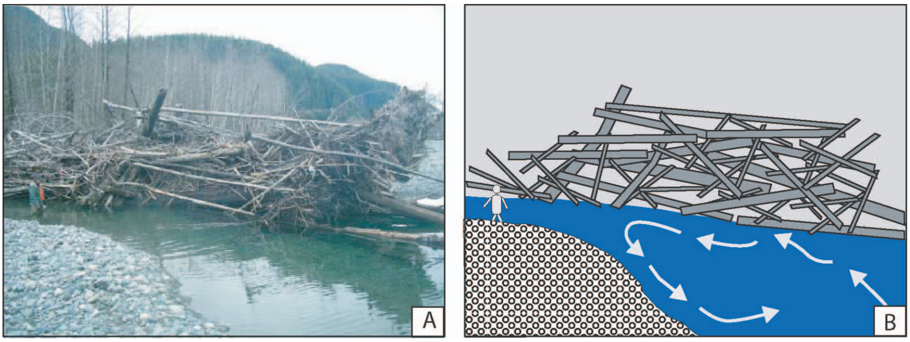

Fig. 5. LWD creates pools providing aquatic habitat. A. Field photo of an LWD accumulation in the Unuk River. B. Representation of the pool formed as a result of channel scour in this area.

cameras operating in the visible part of the spectrum provide a low-cost and feasible solution to monitor an entire river system. Digital techniques used in this study provide encouraging results for LWD detection, mapping, and monitoring that were not possible to achieve for the Unuk River prior to this study. In remote places such as southeast Alaska, remote sensing provides a tool for monitoring LWD, channel morphology, and aquatic habitats with very promising potential for resource management.

This study also shows that some limitations in detection of LWD exist for shadow, vegetation, and solar glint areas. The accuracy of mapping and monitoring LWD and associated channel shifts is dependent on and limited to the spatial resolution of the remote sensing data, as subpixel changes can not be reliably quantified. Use of simultaneously acquired high-resolution thermal infrared images is recommended for possible reduction of such errors.

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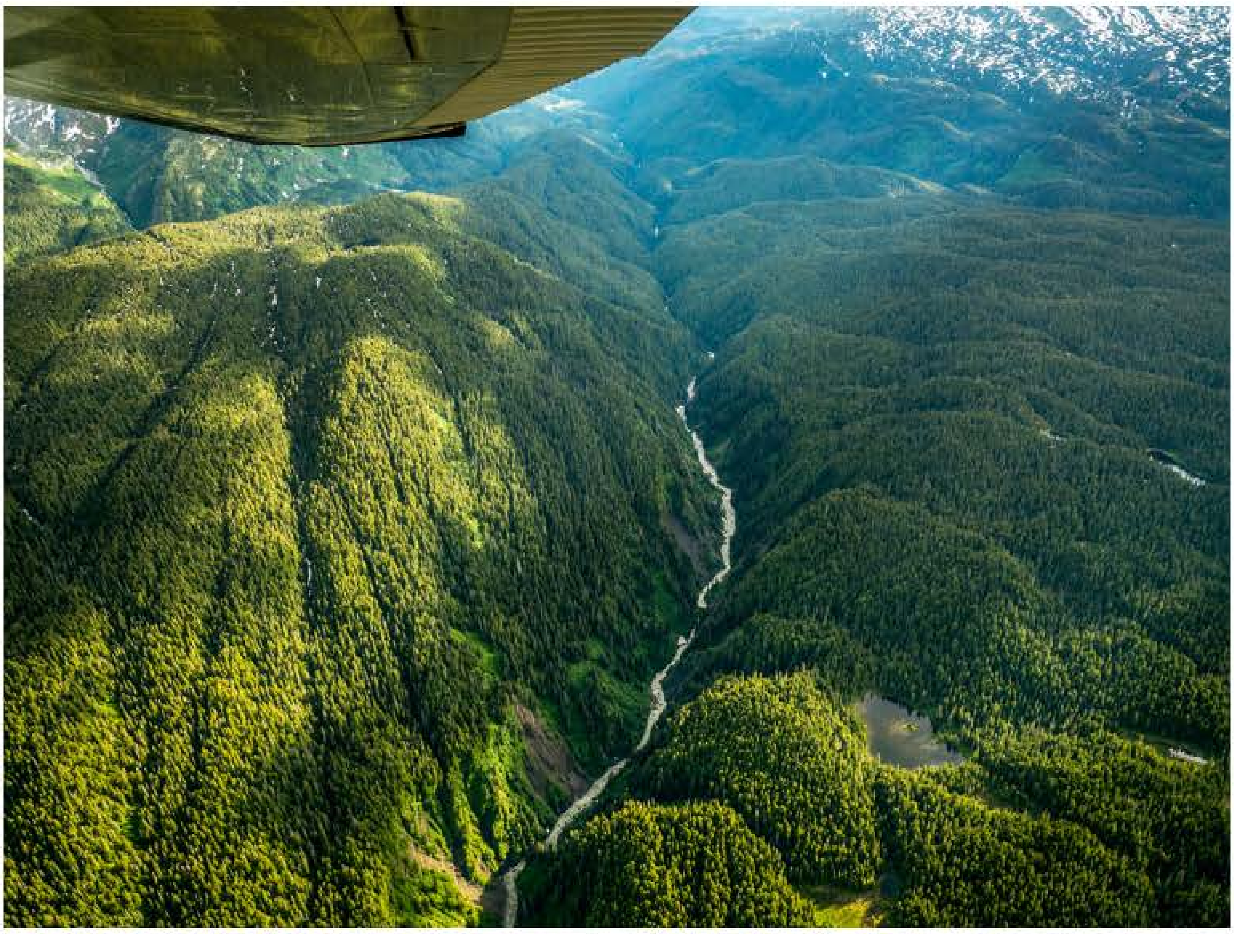
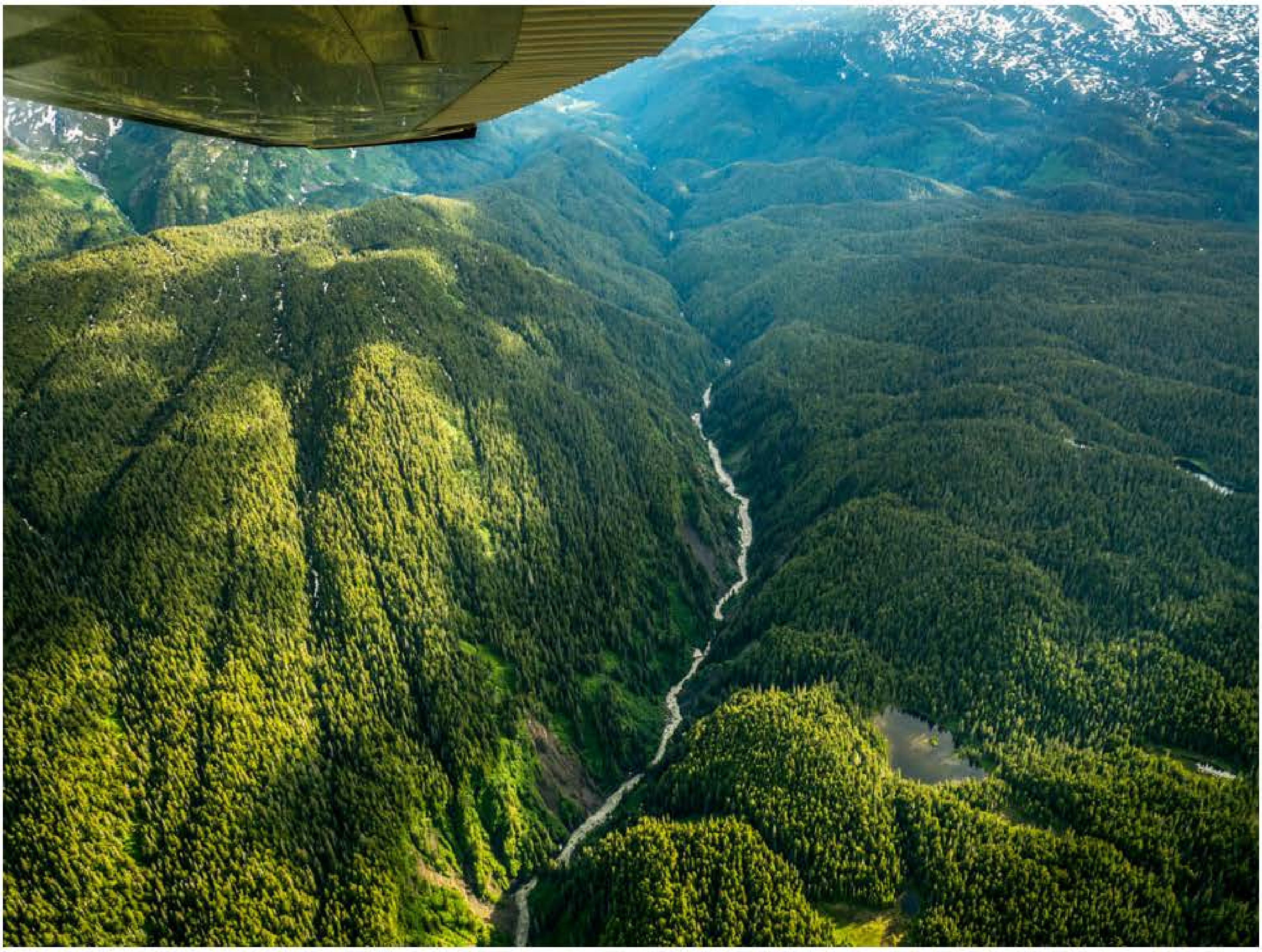


TRAVEL + PLACES

Exploring B.C.'s Threatened Unuk River

BY TRAVIS RUMMEL | MAY 8, 2015



Last summer, Ryan Peterson talked me and Gordon Klco into a first descent of the Unuk River from its source to sea. He made it sound like no big deal: Just hop in our Alpacka packrafts and casually float 100 miles downstream from the mountainous B.C. headwaters to the river mouth in Misty Fjords National Monument in southeast Alaska. We would shoot film along the way to help bring awareness to B.C.'s rampant development of large-scale mines on Transboundary Rivers in the region, in particular a proposed $5.3-billion mine on one of the Unuk's tributaries, the Kerr-Suplhurets-Mitchell mine (KSM).

The expedition ended up being one of the hardest of my life.

Our pilot had to get a little radical as we scouted the immense country, and hopes for a mellow float from Unuk Lake through the upper canyon were dashed once we saw it from the air. The canyon held impassable waterfall rapids that poured into huge strainers; we knew we were in for a full-on bushwhack just to get into the upper river. Shit got real, real quick. It was this realization that might have helped me fill the airsickness bag with the full order of poutine that I had hammered down seconds before boarding our float plane in Smithers. Moments later, the floats of the plane settled onto the water of Unuk Lake.

As we set up camp and watched the northern light turn to alpenglow on the towering peaks around us, we were the most relaxed we would be over the course of our 100 mile journey.

I have a strong distaste for backpacking, and despite our efforts to slim down our kits, we each had 60-pound packs to to haul 10 days of provisions for the 100 miles of the watershed. Our Garmin GPS conveniently lacked any topo lines for the region and we were left mostly with instinct to guide us through the thick canopy of old growth temperate rainforest. There is little to no beta on the Unuk watershed, a rarity in today's world, and Gordon saved our asses with his steadfast route finding. We spent four days hiking 36 hard-earned miles along densely forested ridge lines, rafting over raging tributaries, and tunneling through overhead devil's club. There was zero sign of man.

Incredibly, we hit a high-pressure weather window with sunny skies and no rain – a complete anomaly for the zone, which is one of the wettest in the world – and even with ideal conditions it was still insanely difficult.

We fought our way down one of the Unuk's upper forks, and arriving at the main stem of the river was cause for celebration. We could finally shed the weight of our backpacks for the comfort of our rafts. The Unuk consistently made us feel small, and blowing up our diminutive packrafts along the banks was no different. We were tiny. The Unuk is all glacial runoff, the gradient high. It loomed.

Floating downstream, there were loud consistent knocking sounds over the din of the fast-moving river; the sound traveled through the water column and we could feel it on the bottom of our boats. It took us a minute to figure out that it was coming from boulders being violently pushed downstream along the bed of the river by the heavy current.

There were two lava canyons downstream, where the glacial braids funneled into a deep torrent by the dark walls on both sides. The river became a snaking firehose with whirlpools and eddy fences that pulled and tugged at our weighted rafts. Gordon, an accomplished class V kayaker, led that charge, and without him pointing us through our lines, Ryan and I probably still be out there in the woods, trying to bushwhack around each of the canyons.

To be in the second canyon and to see the myriad of veiled water falls pouring directly from the lava was utterly magical. This was day six and about 75 miles into the journey. The pucker factor was still high given the dynamic hydraulics, but it was hard to deny the beauty of the place.

On day eight, we finally found the mellow braided river we'd been seeking for for the past week. It spread before us in dozens of strands, and we had to keep our flotilla close or we quickly could have ended up miles apart.

On day nine, the river's current gave way to the tidal flats of the mouth, which stretched to the horizon in mist and rain. We had made it to the sea. The torrent of the headwaters was a distant memory, and it was quiet except for the occasional bark from a curious seal. Soon, despite the rain and fog, we heard the glorious rumble of our float plane on approach.

As we taxied for takeoff the pilot asked, somewhat incredulously, what we had been doing on the river. We explained the source-to-sea mission. He paused for a moment and said, "There were more people up there 100 years ago than there are today." It wasn't hard to believe he was right.

Two weeks after we completed our trip through the Unuk watershed, the British Columbia government granted environmental approval for the $5.3-billion KSM mine on the Unuk's main tributary, Sulphurets Creek. The KSM development will create three massive open-pit mines to tap into the world's largest gold and the second-largest copper-gold deposits, plus several underground mines. It will include a processing plant and tailings pile, as well as twin 23-kilometer tunnels.

As the name Sulphurets implies, the area has incredibly high concentrations of sulfides. When water in the form of rain and air mix with exposed sulfides, sulfuric acids are created, or acid mine drainage. Because of this, and because the mine will be located just 20 miles from the Alaskan border, the state of Alaska requested input on the approval process. Canada's Environmental Assessment Agency rejected that request, saying that the KSM mine would likely have no significant adverse environmental effects.

KSM is one of perhaps a dozen large-scale mines being fast-tracked through the permitting process along the BC/AK border. Canadians, of course, have more direct options to fight this. For Alaskans, for the rest of Americans, the only real recourse is to express our concerns for the potential impacts downstream by petitioning the State Department to invoke transboundary treaty agreements.

See XBoundary, the film Rummel and Peterson created to explore these issues, here on AJ.

Supporters of keeping the Transboundary area pristine are rallying around Salmon Beyond Borders, which you can visit at salmonbeyondborders.org.

Photos by Travis Rummel and Ryan Peterson

Cobalt, 1905.

SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY DEPARTMENT

OF

CANADA

FOR THE CALENDAR YEAR

1905

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1906

[No. 26—1906.]

No. 947

To His Excellency the Right Honourable Sir Albert Henry George, Earl Grey, Viscount Howick, Baron Grey of Howick, a Baronet, G. C. M. G., &c., &c., &c., Governor General of Canada.

MAY IT PLEASE YOUR EXCELLENCY,—

The undersigned has the honour to lay before Your Excellency, in compliance with 3 Vic., Chap. 2, Section 6, the Summary Report of the Operations of the Geological Survey Department for the calendar year ending December 31, 1905.

Respectfully submitted.

FRANK OLIVER,
Minister of the Interior.

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SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY OF CANADA

FOR THE CALENDAR YEAR 1905.

The Honourable FRANK OLIVER, M.P.,
Minister of the Interior.

SIR,—The following report, which I have the honour to submit in conformity with the Act under which the Geological Survey is prosecuted, is intended to give a concise statement of the work which was performed by the department during the calendar year 1905. This work, both in the field and at headquarters in Ottawa, consisted entirely of original investigation and was directed primarily to increasing our knowledge of the mineral wealth of Canada. Our researches every year prove more and more conclusively that the mineral resources of this country are both great and varied and that they will constitute an important factor in the growth and prosperity of the Dominion.

While the discovery and making known of the mineral wealth of the country are the main objects aimed at, the work must be carried on in an intelligent and systematic manner, with a view to ultimately obtaining the greatest results. The reasons for some of our methods and operations may, therefore, not be at once understood by those unfamiliar with scientific pursuits.

One of the first things to be done is to ascertain and to show by maps, the distribution, on the ground, of the different rock formations. A certain useful mineral may be confined to one of these; different minerals may likewise be found in other formations, while other rocks again may carry nothing of economic value. The minerals peculiar to the various zones or different areas of rock may have certain peculiarities or signs as to their modes of occurrence. With a knowledge of these conditions, the prospector may confine his search within the area which alone can reward his labours, thus saving his time and affording him a better chance of success.

For the purpose of working out and defining the boundaries of the different rock-formations in unsurveyed or imperfectly known districts, it becomes necessary for the geologist, or his assistant, to make the indispensable topographical surveys. Again, in order to lay down this work properly on paper, a knowledge of mapping is requisite. Then, if we wish to connect together or show the relations of important geological areas, we sometimes require to make accurate astronomical observations, or to run lines of survey where no rocks at all may be exposed, and, in fact, to take every means to secure all the data required for the construction of a good map. It might happen that geological lines, which are really nearly straight, if laid down on the basis of an inaccurate topographical map, would appear distorted, and vice versa.

As much as our field-work is now being done in unsurveyed and even unexplored regions, the most useful geologist is he who is also a good surveyor. Apart from the geological work which he performs, his service to geography is worth more than the cost of both. Owing to the fact that the topographical features everywhere depend upon the geological structure, the geologist becomes the best topographer.

In the last five years the maps which have been actually issued by the department amount to upwards of 150, while 27 more are almost finished and a considerable number are in various stages of drafting and engraving. When all these are issued, the number of separate maps produced in the above five years will amount to nearly half of the total since the commencement of the Survey in 1843.

GEOLOGICAL SOCIETY OF AMERICA.

On the invitation of the Logan Club, which consists of the technical officers of the Geological Survey, the Geological Society of America held its annual meeting for 1905 in Ottawa from the 26th to the 29th December. A number of valuable papers were read and the meeting proved successful.

INTERNATIONAL GEOLOGICAL COMMITTEE.

During its session the members of the central or parent International Geological Committee (Drs. C. Van Hise, C. W. Hayes, R. Bell and F. D. Adams) held a meeting and decided to continue field-work during the coming summer. The region selected for investigation and comparison was that covered by the Haliburton and Bancroft geological maps which have been already printed in colours, but not yet issued by the department, pending the completion of the reports upon this region by Drs. Adams and Barlow.

Drs. Adams and Bell, with the addition of Professor A. P. Coleman of the University of Toronto, were appointed as the Canadian members of the special committee for this work. They are to be joined by three other geologists representing the United States Geological Survey. After completing their work in Ontario the party will proceed to examine one or two districts in the State of New York for the purpose of correlating their geology with that of the above district in Ontario.

CONGRESS OF AMERICANISTS.

Two years ago, at the suggestion of the writer, the International Congress of Americanists, in session at Stuttgart, resolved to hold its next biennial meeting, that of 1906, in the city of Quebec, from the 10th to the 15th of August. A grant of $4,000 to assist in defraying the expenses of the meeting was obtained from the Dominion Government. A strong local committee is making all arrangements for the carrying out of the attractive programme which was decided upon.

Invitations were sent to the governments of all countries throughout the world requesting them to send delegates, and it is expected that a large number of learned men from foreign countries will honour us by their attendance. Numerous papers on important subjects to be read at the meeting have been already promised. The committee of organization consists of Dr. Robert Bell, F.R.S., president; Monsignor Laflamme, Dr. David Boyle and Dr. Franz Boas. The scientific programme being assured, it is hoped the meeting will prove a most agreeable and successful one.

CANADIAN COMMITTEE OF GEOLOGICAL NOMENCLATURE.

The committee on the nomenclature of geological formations in the Dominion, which had originated by the action of the Royal Society of Canada in 1901, has to a great extent been superseded by the more comprehensive international committee, and it did not hold any meeting last year. As it is very desirable that the geology of the two countries should be made to harmonize, it is felt that whatever might be found best for Canada should apply to the United States also, and therefore all the work should be left to the international committee.

FIELD WORK.

The field work, which is the foundation of all the progress made by the Geological Survey, was prosecuted with vigour. Thirty-seven parties, besides the Zinc Commission consisting of three members, went to the field. These were distributed all over the Dominion, from Peel river and the Yukon in the far northwest, to Nova Scotia in the southeast. In some instances the geologists went out alone or with one assistant, and hired temporary help when required; but in most cases they had several persons in their parties.

Most of the field work, as well as that at headquarters, was devoted to economic geology, but at the present time one of the principal duties of the Geological Survey is to produce as complete a geological map of the Dominion as possible, and as large areas still require to be explored for this purpose, a certain amount of energy must be given to this branch of our duties. Three well qualified new members have been added to the temporary staff during the year, namely, Mr. W. H. Collins, Mr. D. D. Cairnes and Mr. W. A. Johnston, all of whom did good field work during the past season.

The instructions given to the numerous field men were all successfully carried out, and although, in remote regions, the work is often difficult and sometimes hazardous, nothing happened to mar the good progress that was made. As in former years, a number of suitable men, not attached to this department, were engaged for field-work either on contract or on salary. The sequel has proved that all the field parties had been judiciously and advantageously placed and the results may be considered the maximum that could be expected. It is satisfactory to know that the work of the Survey during the year has met with the approval of all the important mining interests from the Yukon and British Columbia in the west to Nova Scotia in the east.

Last winter the Board of Trade of Rossland, B.C., asked for a 'structural geological survey' to be made of the Rossland group of mines, and Professor R. W. Brock was designated to undertake this work, assisted by Mr. W. H. Boyd, Dr. G. A. Young, a lapidary and a draftsman. It is proposed to continue this work next year and perhaps longer, and when it is completed to publish a full report on the results. In the meantime Mr. Brock has prepared a preliminary report, which has been published. This report deals with petrographical matters, such as the composition and proper names of the rocks, with questions as to the origin of the ore deposits, the probability of their extension, and the possible discovery of other bodies of ore beyond the limits of those at present worked. The question of the probable depth to which the ores may extend is also discussed. The report likewise describes the methods of working at present employed.

At the request of those interested in mining zinc you appointed an independent commission to visit British Columbia and examine and report on all matters affecting the zinc interest. This commission, by your direction, received $7,500 out of the special grant of $19,000, which had been granted by special appropriation for the work of the Geological Survey in British Columbia and Yukon Territory during the year.

ARCTIC EXPLORATION.

In the summary report for 1904, Mr. Low's explorations of some of our northern coasts by means of the ss. *Neptune* were referred to. During the winter of 1904-5, this gentleman prepared a full report on this work, which was set in type in the spring and summer of 1905; a detailed map and a large number of fine illustrations were made for it. The book was being prepared as an edition de luxe, instead of as an ordinary blue book, under the name of 'The Cruise of the *Neptune*.' It was discovered, however, that Mr. Low, although a regular officer of the Geological Survey, had performed this work under a special commission direct from the Government, and that his report should therefore be published by the Department of Marine and Fisheries. The work is expected to be issued during the summer of 1906.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1905.

Prepared by the Mines Section of the Geological Survey.

(Subject to Revision.)

Product.		Quantity. (a)	Value. (a)
METALLIC.			$
Copper (b)	Lbs.	47,597,502	7,420,451
Gold, Yukon	$8.327,200		
" all other	6,159,633	....	14,486,833
Iron ore (exports, estimated)	Tons.	116,779	125,119
*Pig iron from Canadian ore	"	70,554	1,047,860
Lead (c)	Lbs.	55,961,000	2,634,084
Nickel (d)	"	18,876,315	7,550,526
Silver (e)	Oz.	5,974,875	3,605,957
Cobalt		....	100,000
Other metallic products including zinc		....	180,000
Total metallic		....	37.150,830
NON-METALLIC.			
Asbestus	Short tons.	50,670	1,486,359
Asbestic	"	17,594	16,900
Chromite	"	8,575	93,301
Coal	"	8,775,933	17,658,615
Corundum	"	1,644	149,153
Feldspar	"	11,700	23,400
Graphite	"	541	17,032
Grindstones	"	5,172	57,200
Gypsum	"	435,789	581,543
Limestones for flux in iron furnaces	"	341,614	258,759
Manganese ore (exports)	"	22	1,720
Mica	"	....	168,043
Mineral pigments—			
Barytes	"	3,360	7,500
Ochres	"	5,105	34,675
Mineral water	"	....	100,000
Natural gas (g)		....	314,249
Petroleum (h)	Brls.	634,095	849,687
Phosphate	Tons.	1,300	8,425
Pyrites	"	32,774	123,574
Salt	"	45,370	310,858
Talc	"	500	1,800
Tripolite	"	200	3,600

The total production of pig iron in Canada in 1905 from Canadian and imported ores amounted to 527,932 short tons valued at $6,492,972, of which it is estimated 70,554 tons valued at $1,047,860 should be attributed to Canadian ore and 457,378 short tons valued at $5.445,112 to the ore imported.

(a.) Quantity or value of product marketed. The ton used is that of 2,000 lbs.
(b.) Copper contents of ore, matte, &c., at 15·590 cents per lb.
(c.) Lead contents of ore, &c., at 4·707 cents per lb.
(d.) Nickel contents of ore, matte, &c., at 40 cents per lb.
(e.) Silver contents of ore at 60·352 cents per oz.
(f.) Oven coke, all the production of Nova Scotia, British Columbia and the Northwest Territories.
(g.) Gross return from sale of gas.
(h.) Deduced from the amount paid in bounties and valued at $1 34 per barrel.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1905.

(Subject to Revision).

Product.		Quantity. (a)	Value. (a)
Structural Materials and Clay Products.			$
Cement, natural rock	Brls.	14,184	10,274
" Portland	"	1,346,547	1,913,740
Flagstones			7,650
Granite			209,555
Sands and gravels (exports)	Tons.	366,935	152,805
Sewer pipe			382,000
Slate			21,568
Terra-cotta, fireproofing, etc			64,892
Building material, including bricks, building stone, lime, etc			6,095,000
Total structural materials and clay products			8,857,484
Total all other non-metallic			22,266,393
Total non-metallic			31.123.877
Total metallic			37,150.830
Estimated value of mineral products not returned			300,000
Total, 1905			68,574,707
1904, Total			60,073,897
1903 "			62,600,434
1902 "			63,885,999
1901 "			66,339,158
1900 "			64,618,268
1899 "			49,584,027
1898 "			38,697,021
1897 "			28,661,430
1896 "			22,584,513
1895 "			20,648,964
1894 "			19.931,158
1893 "			20,035,082
1892 "			16,623,417
1891 "			18,976,616
1890 "			16.763,353
1889 "			14,013,113
1888 "			12,518.894
1887 "			11,321,331
1886 "			10,221,255

Minerals Most Inquired For.

The following minerals alphabetically arranged, have been most inquired for during the year :—

Apatite,
Arsenical pyrites,
Asbestus,
Barytes,
Bauxite,
Blende, zinc,
Chrome iron,
Clays for hydraulic cement,
Clays for pottery, bricks, tiles, etc.,
Coal,
Cobalt,
Copper ores,
Corundum,
Feldspar,
Fire clay,
Fluorspar,
Gas, natural,
Gold,
Iron ores,
Ilmenite,
Kaolin,
Limestones for hydraulic cement,
Magnolite,
Marbles,
Mica,
Molybdenite,
Ochres,
Ozokerite,
Petroleum,
Pigments, mineral,
Pitchblende,
Platinum,
Pyrites, iron,
Quicksilver,
Shale, clay,
Silica,
Silver,
Slate,
Talc,
Tungsten,
Tripolite,
Vanadianite,
Witherite,
Zinc.

Petroleum and Natural Gas.

In the list of proposed bulletins given on another page, mention is made of one on Petroleum and Natural Gas. In last year's Summary Report a number of localities are given where petroleum is known to occur in British Columbia and the North-west Territories. The vast deposits of asphalt or tar-sand in the Athabaska region have been described in my report for 1882 and afterwards by Mr. R. G. McConnell.

In 1897 a boring in search of petroleum was made at the expense of the Geological Survey on the west side of the Athabaska river at Pelican rapids. At a depth of nearly a thousand feet, a flow of gas was struck, under high pressure. This prevented any further progress being made in deepening the bore hole. The gas has been blowing off with a roaring noise from the time it was tapped till the present day, a period of more than eight years. At the date of our latest information it is said to show no diminution of pressure.

During the last two seasons, searching for petroleum has been done on a large scale in the district drained by the Flat-head river in the southeastern corner of British Columbia and also in the adjacent tract in the southwestern corner of Alberta. In a number of localities in both these regions, seepages of petroleum have been known for some years. In April, 1905, Mr. Wm. Forest left with me a sample of remarkably good crude petroleum from Sage creek, a branch of Flat-head river.

Last summer a well which was being bored near Pincher Creek in southwestern Alberta close to the mountains was reported to have struck a great flow of oil, but this did not prove to be true. Another well was said to be in progress near Cardston, a short distance further east, but we have no information as to it. At Medicine Hat, gas continues to be obtained at a fair pressure by boring fresh holes in the vicinity of the original discovery.

During the summer of 1905, a boring in search of petroleum was sunk to a considerable depth on the Saskatchewan river under the management of Mr. Eugene Coste, M.E. He has encountered great difficulty in this undertaking on account of the soft and yielding nature of some of the strata passed through.

Last summer the search for petroleum on the eastern peninsula or large Indian Reserve of Manitoulin island was renewed by the Great Northern Oil and Gas Co., Limited, and it was said that a well two or three miles southwest of Wequemakong on the road to Manitowaning, had produced over 100 barrels of oil; also that smaller quantities had been obtained from several other experimental borings on the reserve.

In the southwestern part of the interlake peninsula of Ontario, new producing wells have been bored at several places not far from Leamington. These have been the means of perceptibly increasing the petroleum production of Ontario for the year.

It was proposed to bore for gas at Calgary, under the impression that the Medicine Hat horizon might be struck, but from the knowledge we have of the geology of the region around that town, this horizon is probably buried under a great depth of overlying strata.

The officers of the Survey best acquainted with the geology of this section of Alberta are Messrs. McConnell, Dowling and Cairnes. In regard to the prospect of finding gas by boring at or near Calgary, Mr. R. G. McConnell says the gas-bearing rocks of Langevin are buried at Calgary under several thousand feet of shales and sandstones. A very deep bore-hole would therefore be necessary to reach the horizon of the Langevin beds. No gas has yet been found in the Laramie formation. The crest of an anticlinal crossing the Indian Reserve, which is known to run in a southeasterly direction a few miles southwest of Calgary, would probably afford the most favourable points for boring; but the structure of the district is not well known.

Mr. D. B. Dowling says that two coal-bearing horizons exist, from which gas might come. At Langevin it rises from the lower coal-bearing strata of that locality. At Cassils gas may be found in shallow borings. The Pierre formation is generally composed of compact clays which would hold down any gas which might be escaping from the coals below it. The Laramie is a sandy formation and would not prevent the escape of gas. In the foot-hills the coals of Cassils, Lethbridge and Stair thin out very much. There is a great thickness of rocks at Calgary above the equivalents of the gas-bearing strata of Medicine Hat.

Mr. D. D. Cairnes says the gas of Medicine Hat, Langevin and Cassils comes from rocks of the Belly River Cretaceous series, which are deeply buried at Calgary. At Cassils gas has been struck above the horizon of that of Medicine Hat and Langevin. Near Calgary the best chance for finding gas would be somewhere along an anticlinal which runs S. 73° E. from a point two and a half miles due east of Cochrane street. At the shallowest depth, however, on this anticlinal, any gas which might exist would probably lie 700 to 800 feet deeper than that at Cassils. The next gas horizon would be 600 feet below this last. There is also a third horizon corresponding to the Tar Sands below the last mentioned. If boring be undertaken on the above anticlinal near Calgary, it should be at the lowest surface level. The most promising locality would appear to be in the southwest corner of township 24, range 3 west of the 5th principal meridian, and section 2 or 10 may occupy the most likely position.

COLLECTIONS FOR EDUCATIONAL INSTITUTIONS.

The distribution of collections of Canadian minerals and rocks to educational institutions within the Dominion has been continued as in former years. Collections containing seventy-five specimens of minerals and twenty-five of rocks have been sent to collegiate institutes, high schools and academies, while collections of seventy-five good specimens of minerals, but of smaller size, were sent to schools of lower grades. More applications for these collections were received than could be filled. (They were sent first to those teachers who seemed to be the most enthusiastic and the best qualified to make good use of them.) In every case the recipients of the collections were required to agree to the following conditions : (1) That mineralogy or geology was being actually taught in the school. (2) That the collection was to become the property of the school itself and not of any officer who might be connected therewith. (3) That a suitable case or cabinet was to be provided for its safe keeping. The schools to which collections were sent are enumerated in Dr. Hoffmann's report in the present volume.

The above numbers of specimens are sufficient to cover all the minerals and rocks which the scholars are likely to encounter in nature, and it is as great as they can be expected to learn thoroughly. It was also thought that more good would be accomplished by sending out a large number of such collections, rather than a smaller number of collections containing more but rarer species. The time and money consumed in obtaining the material for these collections have also to be considered, the rarer minerals costing much more than the commoner ones.

CANADIAN ECONOMIC MINERALS AT THE LIEGE INTERNATIONAL EXHIBITION.

A good collection of the more prominent economic minerals of Canada was prepared for the Liege (Belgium) International Exhibition by Mr. R. L. Broadbent, an officer of the Geological Survey, for our Department of Agriculture. As at all previous international exhibitions, from that of London in 1857 to the one which has just been held at Liege, the Canadian collection of economic minerals took first place. In connexion with the last exhibition the following extract of a letter from Mr. Broadbent is of interest :—

LIEGE, (Belgium), November 21, 1905.

'Here Canada is the only country making a thoroughly representative mineral exhibit, and although we did not enter individual exhibits for awards we received a Grand prize for the collective exhibit. The jury expressed themselves as very much pleased with the extent and arrangement of the collection. We also had visits from the Mining and Geological Section of the International Congress of Mining and Metallurgy ; the Congress of Geology ; the Societé Belge Geologie, and others interested in mining and metallurgy, all of whom spoke in the highest terms of the exhibit.

'Belgium being the centre of one of the most important mining regions in Europe, our ores naturally attracted much attention, especially our lead and zinc ores. The largest zinc smelters in the world are here, the Vielle Montagne, and they told me that they would buy Canadian ore providing satisfactory rates could be arranged *re* shipping. With the C.P.R. direct communication with Antwerp, there ought to be a good market here for our ore.

'I also visited the smelting works at Stolberg, Germany. At these works they were using about 2,000 tons of Canadian (B.C.) silver-lead ore per month.

'In addition to the above ores, the inquiries for the most part have been in connexion with chrome, nickel, cobalt, asbestus, mica and corundum, the last mentioned, especially, attracting much attention. It has already a reputation in the European market as a high grade abrasive, and we have in our own section fifteen different exhibits of wheels, discs, &c., manufactured in the U.S., England, France, Germany and Belgium, all from Canadian corundum.'

HYDRAULIC CEMENT.

The manufacture of hydraulic cement, especially by the artificial combining of its ingredients is assuming large proportions in Canada. Numerous inquiries have come to the department during the year for pure limestones and good clays for cement making, especially from the west. Inquiries have also been received for stone which may be calcined and ground for hydraulic cement.

A very pure limestone is quarried near Kananaskis station on the line of the Canadian Pacific railway, on the northeast quarter of section 25, township 24, range 9, west of the 5th principal meridian, Province of Alberta. Its analysis is given on page 20, Part R, Annual Report, Vol. XI, 1898, being No. 695 of the publications of the Geological Survey.

A fairly pure limestone is quarried at the north end of Tunnel mountain in the Province of Alberta. Its analysis is also given on page 20 of the above mentioned Report R of Volume XI, 1898.

Materials for the manufacture of hydraulic cement can be obtained at Bulls Head Plateau, Cypress Hills. See page 786, Geological Survey Report for 1885. Shaganappi point, near Calgary, yields, when calcined, a cement of a very marked hydraulic character, setting under within from four to five minutes. See page 42, Report T, 1886.

The following references as to limestone and hydraulic cement stones mentioned in the reports of the Geological Survey may prove useful :—

Hydraulic Cement Stones.	Page.
Geology of Canada, 1863	804
Catalogue of Section 1, Geological Museum	128, 129
Annual Report for 1895, Part R, Good Hydraulic Limestone	16
" 1895, Part R, Good Hydraulic Limestone	21
" 1899, Part G, Analysis of Limestone	45
" 1899, Part R "	32, 33

Localities for Limestones and Cement Stones.			
Annual Report for	1887–88,	Part R	109
"	1896	" S	159–60
"	1899	" S	122
"	1890–91	" D	42
"	1890–91	" E	39, 191, 198
"	1890–91	" E	63, 158, 172
"	1890–91	" E	176, 183
"	1890–91	" F	13, 54
"	1890–91	" L	33, 35, 41
"	1890–91	" A	38, 48, 58
"	1890–91	" P	16
"	1889	" R	24

UTILIZATION OF LOW-GRADE FUELS.

The invention of the Siemens' Regenerative Gas-furnace and of the improved gas producer engine has given a new value to low-grade bituminous coal, lignites and peat. The Siemens Brothers' producer furnishes the most successful method of applying gaseous fuel for the generation of power. Their patent, No. 167, British, 22nd January, 1861, was granted for 'improvements in furnaces.' The specification states that—'It is an essential part of our invention that the solid fuel used, such as coal, lignite, peat, &c., should be decomposed in a separate apparatus, so that the introduction of solid fuel into the furnace may be altogether avoided, and the gaseous fuel may be heated to a high degree prior to its entering into combustion with atmospheric air, also heated to a high degree, thus causing a great economy of fuel.'

In a paper read before the Canadian Mining Institute, Mr. Dowling says it has been found that the quantity of gas furnished by the lignite is greatly increased by adding an equal quantity of pulverized anthracite, as its fixed carbon 'cuts the tar' yielded by the producer method. Waste tar from any other source may be utilized along with anthracite dust or fine waste anthracite, or with crushed coke made into briquettes. A promising field for further experiments in order to obtain the best results from a variety of cheap materials, is offered in connexion with this process.

Bulletin No. 261 of the United States Geological Survey treats of this subject. Mr. W. R. Campbell, who has been, for two years, connected with the coal-testing plant of that Survey at St. Louis, wrote me in January, 1906, that they had been obtaining some very striking results in the way of the better utilization of low-grade bituminous coals and lignites and probably peat. The coal is converted into producer gas and is used directly in the explosive gas engine. By this method the efficiency of poor fuel is increased nearly or quite 100 per cent. He says: 'Strangely enough our most striking results are on the low-grade lignites of North Dakota and Montana. I presume similar results could be obtained on the same classes of fuel in Canada, and I sincerely hope that our investigations here may be utilized in the development of similar fuels in your country.'

This subject is discussed in Dr. Hoffmann's report in the annual volume of the Geological Survey of Canada for 1882-84. In 1903, Mr. D. B. Dowling of our Survey examined and reported on the lignite of the Souris River region in southern Saskatchewan, which may thus in future be turned to better account than might have been anticipated. These lignites form a continuation of those of North Dakota and Montana, referred to by Mr. Campbell.

METEORITES.

Mr. Robert A. A. Johnston, in addition to his field work in New Brunswick, has continued his studies of Canadian meteorites and has visited some of the localities where falls of these bodies have been reported. We have had casts made and coloured of all Canadian meteorites which are not in possession of the Survey. Mr. Johnston has nearly completed his report on this interesting subject and it will be issued as soon as possible.

LITERATURE OF THE GEOLOGICAL SURVEY.

In the early years of the Survey the publications were not numerous, consisting principally of the annual Reports of Progress and a few maps, with an occasional special report. A few well illustrated Decades on Organic Remains were also published. In 1863 the late Sir W. E. Logan, the first director, issued a resumé of the first twenty year's work of the staff. This was a most useful book and it was intended to follow it by a similar resumé every twenty years thereafter, but forty-three years have since passed away and no further resumé has been written.

About this time there was a hiatus of five years when no Reports of Progress were published, after which their issue was resumed and continued to 1884 inclusive. In 1885 the name was changed to Annual Reports and sixteen volumes of these will have been completed with the issues now in press.

As there was necessarily more or less delay in getting out these full reports, on account of the preparation of maps, palæontological, chemical and other work required for them, it was felt that a preliminary account should be issued of the principal results obtained each year both in the field and at the headquarters of the Survey, together with a general statement as to all the affairs of the department; and to fill this want the publication was commenced in 1872 of an Annual Summary Report. With the growing extent and importance of the work of the Survey, these reports have been expanded year after year and they have been made to include some short complete reports where no further details are required and where it was very undesirable to keep back the information pending the issue of the large Annual Report.

In 1903, I commenced the publication of a series of Bulletins on Economic Minerals, to the progress of which further reference will be made. For some years back the Survey has also been publishing special reports on geological subjects, palæontology, zoology, botany, &c.

INDEX TO ANNUAL REPORTS.

In my Summary Report for 1904, I stated that it was proposed to compile a complete Index to the sixteen volumes of Annual Reports. Work on the Index to the Annual Reports was started by Mr. Frank Nicolas last year, and good progress has been made. The work, of course, involves a great amount of labour, and about 120,000 references have been already prepared. It is expected that the compilation will be completed by the end of this year and it is hoped the printing and binding will not take more than six months. This Index will be a most useful work and will greatly enhance the value of the sixteen large volumes of Annual Reports, which will then become available for easy reference.

The number of publications of the Survey distributed during the year 1905 amounted to 13,861.

After the issue of the Summary Report for last year, the press of Canada was invited to call attention to it and this was, no doubt, the means of making it known to large numbers, who might otherwise not have heard of its publication.

PUBLICATIONS IN 1905 AND 1906.

Summary Report of the Geological Survey of Canada for the calendar year 1904, pp. 392 (with 8 maps and other illustrations). Sessional document.

Report on the Klondike Gold Fields, Part B, Vol. XIV., pp. 71 (with three maps), by R. G. McConnell.

Annual Report of the Mines Section for 1903, Part S. Vol. XVI., pp. 156, by E. D. Ingall and J. McLeish.

Report on Recent Mineral Discoveries on Windy Arm, Tagish lake, Yukon, pp. 12, by R. G. McConnell.

The Mineral Pigments of Canada, pp. 39, by C. W. Willimott.

Geological Report on the Chibougamau Mining Region in the Northern part of the Province of Quebec, pp. 61 (with map), by A. P. Low.

Supplementary List of Publications, pp. 7.

Annual Reports, Vols. XIV. and XV. are in press.

The Annual Report of the Mines Section by Messrs. Ingall and McLeish, (Part S), for 1904 is ready for the press and will be published as soon as possible.

VOL. XIV.

A. Summary for 1901, by Dr. R. Bell.
B. Report on the Klondike Gold Fields, by R. G. McConnell.
F. Report on Ekwan river, Sutton lakes and W. of James Bay, by D. B. Dowling.
H. Report on Sudbury district, by A. Barlow.
J. Report on Perth sheet, by R. W. Ells.
O. Report on the Artesian wells of the Island of Montreal, by F. Adams.
S. Mines Section report, 1902.

VOL. XV. (IN THE BINDERY).

A. Summary for 1902 by R. Rell.
AA. " 1903 "
F. Report on the Souris Coal Fields, by D. B. Dowling.
S. Mines Section report, 1903.

VOL. XVI.

A. Summary for 1904, by R. Bell. (Published).
B. Report on Graham Island, by R. W. Ells. (Published).
C. " the Upper Stewart River region by J. Keele. (In preparation).
CC. " Peel river by C. Camsell. (In preparation).
G. " Yamaska Mountain, Que. by A. C. Young. (Published).
H. " Brome Mountain, Que. by Prof. Dresser. (Published).
S. Mines Section report, 1904. (Published).

BULLETINS.

A bulletin on The Mineral Pigments of Canada by Mr. C. W. Willimott was published during the year. Another bulletin on Barytes in Canada was prepared by Dr. H. S. Poole and is ready for the printer. Bulletins are in preparation and well advanced on The Clay Industries by Dr. Robert Chalmers, and on The Coal Mines of Canada by Theophile Denis.

FIELD-WORK.

As already stated, field-work was performed by no fewer than thirty-seven (37) officers, in addition to those acting on the Zinc Commission which consisted of three members, whose salaries and expenses were also paid out of the funds of the Geological Survey. The following is a list of the field parties of 1905, the objects they had in view and the regions in which they were employed, the latter being given in their order from northwest to southeast. Reports upon most of the work by the men in charge are contained in the following pages.

Mr. Charles Camsell, assisted by Mr. F. E. Camsell, surveyed Peel river, a large stream flowing northward in Mackenzie District. He started for Dawson from Skagway early in the spring before the ice broke up in the rivers and was ready to ascend the Stewart river as soon as it was clear of ice. He followed one of the northern branches of this stream in his canoes to a very long portage across the height-of-land separating it from the source of Wind river, a branch of the Peel. After descending the Peel nearly to the sea, he returned to the Bell river and Rat river, and thence descended the Porcupine to its junction with the Yukon. Here he was picked up by a steamer which took him up to Dawson and he returned in good time to Vancouver. It will be seen by his report that he accomplished a large amount of valuable topographical and geological work in this distant region. Mr. Joseph Keele also proceeded to Dawson before the breaking up of the ice and on the opening of navigation he ascended the Stewart river and continued his investigations of the gold-field on its northern headwaters, which had been commenced the previous year.

Mr. R. G. McConnell's operations were mostly in the district comprised by the headwaters of the White river, to the west of the Yukon. On his way home in the autumn, he made an examination of the recently discovered silver region of Windy Arm. Soon after his return to Ottawa he prepared a report on this district, which was immediately published under the name of 'Recent Mineral Discoveries on Windy Arm, Tagish Lake, Yukon Territory.'

Mr. F. H. Maclaren, who afterwards acted as Mr. McConnell's assistant, preceded him to the Yukon territory and made a survey from Whitehorse westward along the road to Kluane lake, triangulating the tops of the hills and mountains on either side.

Dr. R. W. Ells, assisted by Mr. Sydney Ells, made a geological reconnaisance of Graham island, the largest and most northern of the Queen Charlotte group. Dr. Ells circumnavigated the island and penetrated into the interior in a few places. While passing through British Columbia on his way west, Dr. Ells, accompanied by Dr. H. S. Poole, left the Canadian Pacific railway at Kamloops in order to revisit the coal field of the Nicola valley which he had examined the previous year.

While investigating the geology of Southern Alaska, under instructions from Professor Alfred H. Brooks, geologist in charge, Dr. Frederick E. Wright, of the United States Geological Survey, explored the Unuk river, which flows into Behm canal, opposite Prince of Wales island. Dr. Wright's work having been principally within British Columbia, the United States Survey has generously placed his results at our disposal, as if he had done this work for our department, and they are published as a short report in the present volume.

Mr. Theophile Denis, having been instructed to examine and report upon all the coal mines in the Dominion, visited those of Nova Scotia and afterwards those of the North-west provinces and British Columbia. His report on this work will be published as soon as possible.

Dr. Henry S. Poole, of Halifax, spent the summer in an investigation of the collieries and coal-bearing rocks of the Nanaimo coal field on the eastern side of Vancouver island, and has furnished an excellent report on the subject.

Mr. James M. Macoun, assisted by Mr. William Spreadborough, spent about four months, beginning in May, in continuation of his zoological and botanical work near the International Boundary (49th parallel) between British Columbia and the State of Washington. His field of operations this year was from Midway to Skaget river, the larger branches of which lie within British Columbia. After returning to Ottawa he spent the month of September collecting and studying the aquatic plants of the Ottawa district, in continuation of similar work done on Lake St. Peter the previous year. The latter part of the year was spent in determining and cataloguing the mammals, birds and plants collected during the last five seasons, along the southern boundary of British Columbia.

Professor R. W. Brock, assisted by Mr. W. H. Boyd and Mr. G. A. Young, as already stated, was engaged on a survey of the Rossland group of mines. His preliminary report on this work has been printed as a separate publication.

Mr. D. B. Dowling, assisted by Mr. Geo. S. Malloch, continued his investigations into the geology of the coal-bearing rocks of the Rocky mountains. His principal work the past season was along the Elm and Kananaskis rivers.

Mr. D. D. Cairnes, assisted by Mr. George S. Scott, was employed in an investigation of the geology of a large tract of country lying immediately to the east of the Rocky mountains and southward of the Canadian Pacific railway, which has been topographically surveyed and mapped by Mr. Arthur O. Wheeler, D.L.S. An additional tract, adjoining Mr. Wheeler's sheet to the south, was surveyed both topographically and geologically by Mr. Cairnes.

Mr. J. F. E. Johnston was instructed to proceed to the district around Edmonton, Alberta, in order to collect all possible data in reference to its geology, especially such as bear upon the occurrence of coal or lignite and on the possible existence of petroleum and natural gas in that part of the province.

Dr. Robert Chalmers made a reconnaissance examination of the surface deposits, especially of the clays, of all the more accessible districts throughout the provinces of

Manitoba, Saskatchewan and Alberta. He likewise visited a few places in British Columbia. He was also instructed to collect information of all kinds as to the superficial geology of the districts visited, with a view to further work on this subject in the future.

Mr. W. S. Dobbs was sent to the country lying immediately south of Cape Tatnam on the southwest side of Hudson Bay, proper. On his way to this region, he was to make track surveys of certain rivers, which had not previously been mapped by the Geological Survey. The reported nature of the country south of Cape Tatnam indicated a possibility of the existence there of a considerable tract of rocks older than the Silurian, such as those which occur southwest of Cape Henrietta Maria. In connexion with the construction of a geological map of Canada, it was important to settle this question.

Mr. Owen O'Sullivan, who had surveyed the whole western coast of James Bay in 1904, was instructed to continue this work on the southwestern coast of Hudson Bay lying between York Factory and Cape Henrietta Maria. He, however, succeeded in making a survey only as far as Severn river. Had he completed the projected work of the season, this would have finished the last link of the topographical survey by this department of the entire coast of our great inland sea.

Mr. William McInnes made a geological examination of a large tract around the head waters of the Attawapiskat and Winisk rivers, where it is believed that discoveries of economic minerals may be made.

Mr. W. H. Collins, assisted by Mr. H. C. Cooke made topographical and geological surveys in much of the country lying immediately north of Lake Superior between the Nipigon and Pie rivers.

Mr. W. J. Wilson commenced a regional geological survey of the area lying immediately north of the Sudbury and west of the Temagami sheet. He made good progress, but as the whole of this tract is in a state of nature, topographical surveys require to be made in order to lay down the geology, and probably two more seasons will be required to complete the work.

Dr. A. E. Barlow was instructed to make some more detailed geological examinations of Lake Temagami, for which a new map of the lake on a large scale, which had just been issued by the Ontario Government, would afford some assistance. He was also to continue the detailed geological work southward of the Eastern Arm of the lake, which had been commenced the year before by Dr. G. A. Young.

Mr. E. D. Ingall was engaged the greater part of the season in preparing reports of the Mines Section, but in the latter part of the summer, he proceeded to the Cobalt silver district, accompanied by Mr. J. A. Robert. These gentlemen inspected the district and made surveys of some parts of it.

Mr. C. F. King was employed in the early part of the season in surveying the line of the Temiscaming and Northern Ontario railway and afterwards in assisting Dr. Barlow.

Mr. A. F. Hunter continued the work of tracing the ancient shore lines of the northern part of the interlake peninsula of Ontario in the counties of Simcoe, Grey, Wellington and Bruce.

Professor T. L. Walker of Toronto University, assisted by Mr. R. E. Hore and Mr. Wm. Herridge, was occupied all summer in working out the geology of Muskoka district. Although good progress was made, the district is so extensive that another season will be required before a complete map of its geology can be produced.

Dr. J. W. Spencer, who had already devoted a number of years of his own time to elucidating some of the problems of the Great Lakes and the geological history of Niagara Falls and river, was employed all summer in completing his investigations of this history. The time seemed opportune for this work, on account of its great interest and the attention which it is attracting and also in relation to questions which are now prominent in connexion with the position of the International Boundary line at the Falls and as to the utilization of the cataract for generating power. Dr. Spencer's results are highly interesting and important.

Mr. W. A. Johnston, assisted by Mr. J. B. Tett finished working out the geology of the Peterborough sheet (Ontario) which represents the same area as the other Ontario sheets, namely 72 miles from east to west, by 48 from north to south.

Professor Ernest Haycock, assisted by Mr. Strong, continued to investigate the details of the geology of the Upper Laurentian rocks of a part of the counties of Labelle and Wright, on which he had been engaged the previous year, and it will require another season to complete the area it is proposed to map out.

Mr. C. W. Willimott devoted part of the season to the collection of minerals to be used in making up educational collections, and a part was required to exploit some new localities for a reddish brecciated limestone marble and also some varieties of greenish serpentine marbles. One of the former proved to be a sound and handsome stone, capable of a good polish, and it has been already used to decorate the main corridor of the House of Commons at Ottawa.

Mr. A. P. Low proceeded to Lake Chibougamau, northwest of Lake St. John in northern Quebec, where during the previous summer, Mr. J. Obalski, Inspector of Mines of the province of Quebec, had discovered asbestus of good quality and in considerable quantities, besides copper ore and a large quartz vein, holding small particles of free gold. These discoveries were referred to in my report for 1904 (page 33), where attention was also called to the fact that the late Mr. James Richardson of the Geological staff had found copper pyrites in the same neighbourhood in 1870. Mr. Low traced the distribution of the Huronian rocks, in which these minerals occur, for some distance to the westward of Chibougamau lake.

Prof. J. A. Dresser, who had in previous years worked out the geology of Orford and Brome mountains, devoted the past season to another of the Monteregian hills—Montarville mountain. He also made a collection of fossils from the shales around the base of the mountain, which comprises more species than had ever before been found in these rocks.

Professor John Macoun spent the summer months in collecting and cataloguing the plants of the north shore of the Lower St. Lawrence river. The other parts of the year were devoted to making a preliminary draft of a work on the mammals of Canada, in which much attention is given to their habits and distribution. Progress has been made towards completing a Flora of the Vicinity of Ottawa and the Flora of the Rocky Mountain Park, which latter is now nearly ready for the printer. Some attention has been given to the government museum at Banff, in this park, which is under the general supervision of the Geological Survey. Professor Macoun continues to add to his large stock of new information in regard to the Fungi, Lichens, Mosses, Algae and other cryptogamous plants of Canada, which have not yet been included in the published volumes of his Catalogue of Canadian Plants.

Mr. Lawrence M. Lambe spent some time on the north shore of Chaleur bay, in collecting fossil fishes from the Devonian rocks. By diligent search and by blasting the rocks, he secured a number of valuable specimens.

Professor W. A. Parks undertook some field work for the Survey in the western part of central New Brunswick, along the Nipisiguit river. In addition to this work, his petrographical studies of the specimens brought home are expected to throw some new light on the different problems of the geology of this part of the province.

Mr. Robert A. A. Johnston, assisted by Mr. Bronson, completed, as far as intended at present, the geology of Charlotte county, New Brunswick. His labours have been the means of improving very much the geological map of the southwestern part of the province.

Mr. Hugh Fletcher, assisted by Mr. A. T. McKinnon, spent the season at various localities along the Bay of Fundy side of Nova Scotia. Special attention was devoted to the examination and mapping of the iron ore bands of Nictaux and Torbrook.

Mr. E. R. Faribault was assisted in the field work by Messrs. James M. Cruikshank and A. Cameron, and in the map-making by Major F. O'Farrell. Their work lay mostly in the districts lying to the southwest of Halifax and consisted in a careful survey, so as to map on a large scale, all the features of each district, together with an accurate representation of the gold bearing quartz veins or leads.

My own field-work consisted partly of an inspection of the Klondike gold district and the collection of information as to the occurrence of coal or lignite in the Yukon Territory. Returning from this Territory, I visited Nanaimo coal field in order better to determine what further geological work was most needed in that region and how it might best be carried out. The mines of the various districts in the southern parts of British Columbia were visited and inspected underground as far as time would permit. I have to express my thanks to the officers of all the mines visited for their invariable courtesy and for affording me every facility for examining the mines themselves, the mining machinery and reduction works. At Fernie, I was indebted to Messrs. James McEvoy, W. W. Leach and H. Frechette, all of whom were formerly connected with the Geological Survey, for conducting me through the collieries and coking yards.

In November, I spent some days in looking over the mining and prospecting operations in the Cobalt silver district.

The work of the Survey at headquarters during the year has been vigorously carried on in all the branches. The accompanying reports by the various officers in charge are so full and explanatory that no further remarks are necessary.

The correspondence of the department continued to be large, but all letters were promptly and fully answered. We received, as usual, many questions and inquiries, relating to a variety of scientific subjects, besides those connected with geology, palæontology, mineralogy, mining, surveying, exploring, mapping; chemistry, metallurgy, archæology, botany, zoology, etc.; and all these were answered in due course.

HEAD WATERS OF WHITE RIVER.

YUKON.

Mr. R. G. McConnell.

Work was continued during the season of 1905 in the district about the head of White river. The time available for work in this distant region is somewhat brief as the summer is short and a considerable portion of it is occupied in travelling. On this account the examination of the district necessarily partook of the character of a reconnaissance. A topographic survey of the district was made by Mr. F. H. Maclaren, the topographer of the party.

TOPOGRAPHY.

The region examined lies along the landward base of the St. Elias range, east of the Alaskan boundary, and is included in the drainage basin of White river, one of the principal western tributaries of the Yukon river.

The north eastern slope of the St. Elias range is largely drained by various branches of White river, the principal of which are the Kluane, Donjek and the Generk rivers. The trunk stream bends to the northwest and crosses the Alaskan boundary before reaching the mountains.

The Kluane river flows out of Kluane lake, a large sheet of water about forty miles in length, lying along the base of the St. Elias range, and fed mostly by Slims river, flowing from the Kaskawulsh glacier.

The Donjek is a typical glacial stream. Its muddy waters, flowing in numerous branching channels, spread out in seasons of flood across a bare gravel flood plain from one to three miles in width. The channels change continually, new ones being constantly opened, and old ones blocked, by the rapid, overloaded streams. Bars easily fordable at onehour are often impassable the next.

The Donjek appears to issue from a large glacier which occupies the whole width of its valley a few miles inside the mountains. I was informed, however, by a prospector who had explored its upper waters, that the glacier is fed by an ice stream descending a tributary valley from the northwest and that the upper portion of the main valley is free from ice and is partially wooded.

The Generk, though scarcely twelve miles in length, carries a large quantity of water and is one of the principal feeders of White river. It heads in the Klutlan glacier and flows northward parallel to, and a few miles east of, the Alaskan boundary. Like the Donjek, it has built up a wide gravel flood plain through which it winds in a multitude of interlacing channels.

The Klutlan glacier has a width, at present, of from two to four miles. It has evidently receded rapidly in recent years as it is bordered on the south by a wide belt of rough morainic country now free from ice. Its rate of motion is slow, and in places it appears to be stationary, as trees occur growing on shallow soil underlaid by clear blue ice. The lower portion and sides of the glacier are buried in debris. A ridge of fresh uncovered ice in the upper central portion of the glacier, only seen from a distance, suggests an active glacier over-riding an older almost stationary ice and gravel mass.

The St. Elias Alps, the principal topographic feature, form the southwest boundary of the district, and extend to the sea. The mountains and mountain ridges of this range are characterized by extreme boldness of outline. Steep slopes, precipitous cliffs and high broken peaks and crests prevail. The larger streams such as the Donjek and St. Clair have cut deep, wide valleys back into the heart of the range, while the smaller ones are usually inclosed in narrow steep-sided and often impassable cañons. The central portion of the range and all the higher mountains are covered with deep continuous snow fields, and glaciers—some of the first magnitude—are present everywhere.

The St. Elias range is bordered along its whole northeastern front by a wide continuous depression occupied in different portions of its length by a number of small streams. The depression is crossed transversely by all the large streams flowing from the range and evidently antedates by a long period the initiation of the present drainage system. The summit of the depression between Kluane river and the Donjek has an elevation of 1,500 feet above the former, and between the Donjek and the Generk of about 700 feet.

East of the depression is a broken upland cut by a system of interlocking valleys into mountain groups and ridges usually rising from three to four thousand feet above the valley flats. The mountains while rugged in places are more worn and are tamer in appearance than those in the St. Elias range, and their inferior height has also prevented the great accumulation of snow and ice which forms such a conspicuous feature of the latter.

FOREST.

The forest trees are few in number and include only the white and black spruces (*Picea alba* and *P. nigra*), the aspen (*Populus tremuloides*) and, occasionally, the balsam poplar (*Populus balsamifera*), and the birch (*Betula papyrifera*). The forest is sparse as a rule and ceases at an elevation of 4,000 feet above the sea.

GEOLOGY.

The geology of the district proved less interesting than was expected, as the older rocks along most of the St. Elias range and for some distance eastward, are buried beneath a great thickness of comparatively recent effusive and fragmental volcanics.

Tertiary.

A band of rocks referred to the Tertiary follows the St. Elias range from the Duke river to the St. Clair. They are well exposed on a small stream which enters the Donjek from the west a mile above the mouth of Wade creek. They consist here mostly of grayish conglomerates often only slightly indurated, formed of smooth and well rolled pebbles of quartz, quartzite, slate, chert and diorite. A band of red, iron-stained conglomerate occurs at the base of the formation, derived mostly from the debris of underlying dioritic rocks. With the conglomerate are beds of grayish and yellowish tufaceous sandstones, dark, often carbonaceous shales, and occasional beds of lignite.

The conglomerates and associated clastic beds of the Tertiary alternate with numerous lava sheets from fifteen to one hundred feet in thickness which appear to be contemporaneous with them. The lava sheets are usually andesitic in character and, in places, are slightly vesicular. They have smooth surfaces and decrease in thickness gradually towards their termination. They conform perfectly with the inclosing clastic beds even when the latter are steeply tilted. No dikes connecting with sheets were observed. The vulcanism which accompanied the deposition of the Tertiary beds was of long duration, as the latter are overlaid by at least 4,000 feet of effusive and fragmental volcanic rocks.

The Tertiary beds which outcrop along Maple creek consist mostly of shales and sandstone with some conglomerate and an occasional lignite seam. On Granite creek and east of the St. Clair river conglomerate is the principal constituent of the formation.

The Tertiary beds are strongly folded in places, especially near the mountains, and therefore antedate in age the last movements which produced the St. Elias range. No determinable fossils were obtained from them.

Mesozoic Beds.

The mountains of the St. Elias range fronting on Kluane lake are largely built of hard greenish tufaceous beds alternating with dark shales, breccias and, occasionally, agglomerates. Similar rocks outcrop at the cañon of Duke creek and also at the lower cañon of Burwash creek. The beds of this series, as a rule, are sharply folded and, in places, are overturned and broken. The rocks, usually hard, are more or less altered, and occasionally pass into green chloritic schists.

Specimens of the Triassic fossil *monotis subcircularis*, were obtained from a band of dark shales outcropping near the centre of the lower cañon of Burwash creek. It is unlikely that the whole series is referable to one period as, in places, it is many thousands of feet in thickness. It probably represents the product of repeated volcanic outbursts, possibly continued into the Tertiary.

Upper Palaeozoic.

The rocks referred to the upper Palaeozoic consist mostly of massive limestones and marbles associated with hard shales and slates and feldspathic sandstones. A good section of these rocks is displayed along the Donjek valley from the point where it leaves the St. Elias range up to the Donjek glacier, a distance of about seven miles. The outer range at this point is built of diorite. The diorite is followed by a wide band of crushed, reddish weathering limestone underlaid by grayish massive limestones and alternating limestones aud shales. The latter are succeeded by feldspathic sandstones and limestones, both holding fossils of Carboniferous age. The tufaceous beds are cut by diorite, above which is a second band of massive gray limestone, followed by dark slates, altered in places into a schist. The slates are succeeded by reddish granites and diorites.

The limestones and associated rocks strike in a northwesterly direction and dip uniformly to the northeast at angles of from 30° to 70°. This outward dip is unusual in the great mountain ranges of the west, and is not a constant feature of the St. Elias range, although it occurs at several points.

At the head of Burwash creek the outer range of the St. Elias mountains is built of massive limestone, and bands of limestones and shales similar to those on the Donjek but dipping at a high angle in the opposite direction. North of the limestones—and apparently underlying them—are hard feldspathic quartzites, dark shales and iron-stained tufaceous beds. These beds have a nearly vertical attitude and their age relationship to the limestones is uncertain.

The mountain groups northeast of the trail from Burwash creek to the Donjek are built largely of slates, hard tufaceous rocks and limestones similar to those in the St. Elias range. West of the Donjek the limestones disappear and the rocks outcropping along the valleys of Wolverine and Harris creeks consist mostly of hard, imperfectly cleaved slates and tuffs, cut by numerous diorite dikes and by a granite area.

The rough grouping of the clastic rocks of the district into the three series briefly described above is only intended as a provisional one and will doubtless be greatly modified when the region is examined in detail.

Massive Igneous Rocks.

Andesites and Basalts.

Effusive rocks have a wide distribution in the district. A large area commencing within a few miles of Kluane lake crosses Duke river valley and extends northward to the 'gap' of this stream. A second small area—probably a disconnected portion of the first—occurs south of upper Burwash creek. Between the Donjek and the Generk the mountains of the St. Elias range, and a wide flanking plateau, are built entirely of these rocks and they extend westward across the Generk to the Alaskan boundary.

The effusives rest on the Tertiary north of the Donjek and are therefore the youngest rocks in the district. The lava sheets in the Duke river area are nearly horizontal and show no signs of disturbance. North of the Donjek the sheets are often sharply bent and in places are broken and faulted.

The effusives in this series consist mainly of augite andesites of a somewhat basic type, and basalts. The sheets range in thickness from a few feet to several hundred feet, and are usually separated by tufaceous beds varying in texture from a fine ash to a coarse breccia. The series has a minium thickness of 5,000 feet.

Amygdaloids.

Bands of a green amygdaloidal rock occur at several points in the district, usually associated with the Mesozoic tufaceous beds. The upper portion of the lower cañon of Burwash creek is cut through this rock, and it was also found at the upper cañon of Tatamagouche creek and on one of the creeks flowing into Kluane lake. It is important as it is supposed to be the source of the native copper which occurs loose in so many of the creeks of the district. Lithologically it is a vesicular diabase. The augite in the section examined is mostly altered to chlorite, and the cavities are filled with calcite usually surrounded by a ring of chlorite. A similar rock—also associated with copper deposits—occurs in the Windy Arm district.

Gabbro-diorite.

This is a dark gray rather fine textured intrusive, widely distributed in stocks and dikes throughout the district. It is a hard rock and in the St. Elias range usually weathers into high bold peaks. It cuts the beds of the Mesozoic series but is older than those referred to the Tertiary. While usually massive it is slightly sheared in places and is occasionally seamed with small quartz veins.

The mineral constituents of the gabbro-diorite exhibit considerable variety in different sections. In places the rock is a typical diorite consisting essentially of hornblende, some biotite, and labradorite. This type passes by the substitution of augite for hornblende into a gabbroic variety, and by the addition of quartz and microperthite into a grano-diorite.

Quartz Porphyrite.

A yellowish porphyritic rock showing, in thin sections, a fine grained quartz and feldspar base, through which crystals of a plagioclase feldspar, biotite and quartz, are porphyritically distributed, outcrops in considerable masses along Burwash creek. It is probably the youngest intrusive on the creek.

Dunite.

Areas of dunite, partially altered in places into serpentine, occur on Burwash creek and on a branch of Quill creek

ECONOMIC GEOLOGY.

Coarse gold occurs in nearly all the streams in the district except those flowing over the recent volcanic rock, but no rich concentrations have so far been found. Brief descriptions of all the creeks worked, with the exception of Arch creek, are given in the

Summary Report of 1904 and need not be repeated here. Ruby creek, the centre of mining operations in 1904, is now almost abandoned and the miners have moved on to Fourth-of-July creek, a parallel stream flowing out of the same range. A few claims are being worked on Fourth-of-July below the mouth of Snyder creek. A feature of the workings of this creek is that the auriferous gravels rest on a band of boulder clay which constitutes the bed rock. The boulder clay band has not been pierced, and there is a possibility—as pointed out in last year's Summary—that pay-gravels may exist beneath it. The gravel bed overlying the boulder clay is shallow and easily mined, but carries comparatively light values.

A large amount of work was done on Bullion creek by the Bullion Hydraulic Co. This company has taken over most of the ground below the cañon and spent the season in installing a hydraulic plant. A flume five feet by three and a half feet, with intake on claim No. 26, has been built down the valley to claim No. 48, a distance of about a mile. In places where the valley slopes were favourable the flume is replaced by short ditches. The grade of the creek is steep and a head of 175 feet is gained in this distance. The water is supplied to the monitor through a pipe 1200 feet in length and thirty-six inches in diameter at the intake. At the time of my visit excavations for a bed rock flume were in progress. The monitor was employed for this purpose and appeared to be doing very efficient work. Preparations were not completed in time to admit of a satisfactory test of the creek before the season closed.

A number of claims were worked on Burwash creek throughout the season, both above and below the cañon, with varying results. The values in the upper part of the creek have proved generally unsatisfactory and some of the claims have been abandoned. A stretch of fair ground several claims in length has been found in the valley about a mile above the cañon and a second one at the foot of the cañon. The returns from the best claims seldom exceed ten dollars per day per man. Mining on Burwash creek is attended with peculiar difficulties; the creek is subject to sudden floods and on several occasions last season wing dams and drains—the result of weeks of hard work—were destroyed by the rushing waters in a few minutes.

Some prospecting has been done on Tatamagouche creek, a northern branch of Burwash creek. This creek is similar in character to Burwash creek and cuts the same rocks. It enters Burwash creek through a long cañon above which the valley is wide and open.

Further to the west is Arch creek, the latest discovery in the district. This stream heads with a branch of Quill creek and flows westward into the Donjek. Its grade averages about 300 feet to the mile. Like most of the creeks of the district the valley contracts at one point into a narrow cañon. The cañon is situated about a mile above the mouth of the valley and is about three quarters of a mile in length. Half a mile above it is a second small cañon 200 yards in length, above which the valley widens out and is bottomed with narrow flats and bordered in places with terraced slopes.

The rocks outcropping along the valley consist of hard tuffs, slates and limestones cut by several small diorite masses. The name of the creek is derived from an arch like opening in a band of limestone crossing the cañon through which the stream has cut a passage. The slates and tuffs are traversed by small quartz veins from which the gold in the creek has probably been derived.

At the time of my visit a few claims were being worked in the cañon, where the gravels are comparatively shallow. In the upper part of the valley the gravels deepen, and the few holes sunk have failed to reach bed rock. The gold obtained is found on or near bed rock, and consists mostly of heavy grains and small nuggets. The largest nugget found was obtained from No. 9 claim in the cañon, and weighed over three ounces. It contained considerable quartz, and its rough surface showed that it had not travelled far. No ground yielding more than good wages has been found on the creek up to the present.

It is somewhat remarkable considering the number of creeks in the district on which coarse gold has been found, and the wide area over which they are distributed, that occasional rich concentrations have not been found. The chances of such discoveries are, of course, not by any means exhausted, as none of the creeks have been fully prospected, and some of them have scarcely been touched, and it is this which keeps the miner in the field. The present yield of the best claims of from \$6 to \$10 per day can hardly be considered wages in a region where the cost of supplies is so excessive and the working season is so short and broken.

COPPER.

Native copper is almost as widely distributed in the creeks of the district as gold. It is found on Bullion, Sheep and other creeks flowing from the St. Elias range, and also on Burwash, Tatamagouche and Arch creeks, in the region between Kluane river and the Donjek. It is not found on Ruby, Fourth-of-July, or any of the streams cutting the old schists of the Ruby range.

The principal copper creek in the White River district is Kletsan creek. This stream is situated in Alaska, about four miles west of the International Boundary. It was examined by Mr. A. H. Brooks of the U. S. Geological Survey in 1898. Brooks found that the stream copper, in part at least, was derived from calcite veins cutting a dioritic rock exposed along the valley. These copper-bearing rocks do not extend far in an easterly direction, as they are soon buried beneath a great accumulation of young volcanic rocks.

Areas of a dioritic rock apparently similar to that on Kletsan creek occur on most of the copper-bearing creeks in the Kluane district, but no mineral discoveries have so far been made in them.

The upper part of Burwash Creek cañon is cut through a green, often iron stained, diabase amygdaloid. This rock is cut by a few small calcite veins, which are usually stained with copper and carry small quantities of chalcopyrite and occasional grains of native copper. Similar copper-stained amygdaloids occur on Tatamagouche and several other creeks in the district. No veins of commercial importance have been found in them up to the present.

ATIVE SILVER.

Occasional coarse grains and small rough nuggets of native silver occur with the gold on Burwash and Arch creeks.

COAL.

Lignite coal of good quality occurs throughout the Tertiary area extending along the foot of the St. Elias range from the Donjek to the St. Clair. The veins vary in thickness from a few inches up to four feet.

WINDY ARM DISTRICT, NORTHWESTERN BRITISH COLUMBIA.

Mr. R. G. McConnell

On the way back from the White River country a few days were spent late in the season examining the recent mineral discoveries on Windy Arm, Tagish lake.

SITUATION AND COMMUNICATIONS.

The principal ore deposits so far discovered in this district occur on the west side of Windy Arm, a southerly branch of Lake Tagish. Tagish lake forms part of a chain of long narrow lakes, including, in order from north to south, Lakes Lindeman, Bennett, Nares, Tagish and Marsh, which commence well within the Coast range of mountains and extend northward and eastward for a distance of nearly seventy miles. The general direction of these lakes is north and south, with the exception of Lake Nares and the upper part of Tagish lake, which have an east and west alignment. Windy Arm joins Tagish lake near its head and extends south for a distance of twelve miles. Its course is nearly parallel to that of Bennett lake, and the two sheets of water inclose an area of high mountainous country about eight miles in width, the scene of the principal recent discoveries.

The White Pass and Yukon Railway affords easy communication to the new mining district. This line, after crossing the Coast range, follows the east shore of Bennett Lake to Caribou Crossing, at the foot of the lake, at which point steamers run to Conrad City, on Windy Arm, the shipping point of the mines. The total distance from tide water at Skagway to Conrad City is 79 miles, of which 67·5 miles is made at present by rail and 11·5 miles by water. A railway can easily be built from Caribou Crossing along the shores of Lake Nares, Tagish lake and Windy Arm to Conrad City, and surveys for one have already been made by the engineers of the White Pass and Yukon Railway. A second route from Log Cabin station, on the main line of the White Pass and Yukon Railway, above Bennett lake, by way of Tutshi lake to Windy Arm, has also been proposed. The distance to tide water would be reduced considerably by this route, but the mileage of new line necessary would be greater.

CHARACTER OF COUNTRY.

The country bordering the northeastern slope of the Coast range, including the Windy Arm mining district, may be characterized generally as consisting of a system of wide valleys, often interlocking in a peculiar manner, separated by mountain groups and ridges rising from 4,000 to 5,000 feet above the valley flats. Most of the valleys are bottomed at intervals with long narrow deep lakes, due to the blocking of the channel at various points with glacial drift. The uplands are usually fairly regular in outline, but in places are exceedingly rugged and are often deeply incised by the numerous small streams which flow down their sides.

The forest growth is sparse and is confined to the valley flats and lower slopes of the mountains. At an elevation of 2,000 feet above the valley bottoms the forest practically ceases. The principal trees in the district are the white and black spruces, the aspen, the balsam poplar, the balsam fir and the black pine. The supply of rough lumber within easy distance of the camp suitable for ordinary mining purposes is ample for some years at least.

GEOLOGY.

The mineralized area on Windy Arm is situated a few miles northeast of the long granite batholith of the Coast range. This great igneous mass extends from the southern boundary of British Columbia in a northwestern direction to latitude 62° north, a distance of fully 1,000 miles, and constitutes one of the largest continuous granite areas in the world. Mineralized areas have been found at a number of points in both the older clastic and younger intrusive rocks, flanking the Coast range batholith, and it is probable that further discoveries will be made, as the adjoining country, especially on the landward side of the range, has so far been only imperfectly prospected.

The clastic rocks flanking the Coast range granite in the vicinity of Bennett and Tagish lakes, consist of crystalline limestones, coarse slates passing in places into schists and interbanded with quartzites, limestones and hard, fine grained cherty beds, and dark argillites alternating with tufaceous sandstones, coarse conglomerates, and occasional limestone bands.

A section from Tagish lake up Windy Arm and along the short valley connecting Windy Arm with Tutshi lake was studied in some detail. Near the mouth of Windy Arm the rocks consist of light grayish heavily bedded crystalline limestone, striking in a northwesterly direction. These rocks have an extensive development along the southeastern shore of Tagish lake and the lower part of Taku Arm. They also extend in a wide band from a point near the west end of Tagish lake southeastward to Atlin lake.

The limestones are succeeded going south along Windy Arm by a set of beds which will be referred to as the Tagish series. This series consists largely of dark, hard argillaceous rocks, coarsely bedded and occasionally passing into impure quartzites. The slates are interbanded in places with crystalline limestones and also include numerous beds and bands of fine grained compact cherty rocks, probably hardened by the infiltration of siliceous waters. Occasional bands of amygdaloid are also present. The relationship of the Tagish series to the crystalline limestone was not ascertained. The latter is probably Carboniferous in age.

The Tagish series is replaced ascending Windy Arm by basic igneous rocks usually porphyritic in character. The porphyrites and associated rocks outcrop along the shores of the lake for a distance of five miles and are then succeeded by a series of clastic rocks for which the name Tutshi series is proposed. The Tutshi series consists mostly of dark well cleaved argillites, softer and less altered than those in the Tagish series. The argillites alternate in places with fine grained tufaceous sandstones and occasional beds of grayish limestone. Bands of conglomerate and agglomerate also occur in this formation, the former holding well rounded pebbles of slate, quartzites and granite. The Tutshi series resembles lithologically a formation in the Atlin district, holding fossils supposed to be of Jurassic age (Part B. Annual Report Geological Survey of Canada Volume 12, 1899, page 26).

A parallel section along the lower part of Bennett lake cuts the same formations as those exposed on Windy Arm, except that the Tagish series is partly replaced by an outlying granite area. The northeastern boundary of the main Coast range granite mass crosses Lake Bennett at Pavey station, five miles below the head of the lake.

The massive igneous rocks of the district consist of granites and porphyrites and allied rocks.

A granite area about three miles in width occurs at the lower end of Bennett lake, and strikes southward towards the head of the south branch of Montana creek. The granite is a medium grained unsheared gray rock consisting of quartz, orthoclase, oligoclase biotite and hornblende. Dikes of a similar character cut the Tagish series on Windy Arm.

The porphyrite is the most important rock, economically, in the district, as most of the veins discovered up to the present occur in it. It crosses from Windy Arm to Bennett lake in a band from three to five miles in width, and also extends for some distance east of Windy Arm. It is a dark grayish, usually rather fine grained rock, distinctly porphyritic as a rule. Thin sections show feldspar phœnocrysts scattered through a crystalline base, consisting mostly of small feldspar crystals and chlorite. Augite is occasionally present, and calcite is abundant in the sections examined. In many places the porphyrite is heavily charged with iron, and weathers to a rusty colour. At Red Deer mountain it either passes into, or is replaced by, a medium grained rock with the character and composition of gabbro.

The principal structural feature of the porphyrite-gabbro are the systems of strong jointage planes everywhere present. The joints, like the veins, show little parallelism in either dip or strike in different parts of the area.

GENERAL CHARACTER OF VEINS.

The largest and most persistent veins so far discovered occur in the porphyrite area. They are not, however, confined to this formation, a few occurring in the granite and some, also, in the slates The veins occupy typical clean-cut fissures with regular walls often slickensided and grooved. They are comparatively narrow but as a rule exhibit remarkable persistency in strike. The Uranus vein, with a width of from one to four feet, has been traced by small openings and surface showings for a distance of about 1,500 feet and may extend much farther, while the Montana vein, with a maximum width of five feet in the portion explored, has apparently been cut at a distance of 1,600 feet from the main workings and may also, of course, be very much longer. The Venus No. 2 lead (the largest seen by the writer) has a width of nine feet at two openings about 400 feet apart, and must extend for long distances in both directions. Numerous other veins such as the M. and M., the Joe Petty and Venus No. 1 are traceable by surface outcrops for several hundred feet. Portions of all these veins are concealed by slide rocks, and their full length was not ascertained.

The dip and strike of the veins are exceedingly irregular. The Montana vein strikes N. 43 W., while the direction of Venus No. 2 is about N. 42 E. The M. and M. strikes nearly north and south. The dips are nearly all to the south and west and vary in steepness from 12° in the Montana to 50° in Venus No. 1.

The gangue in all the veins is mainly quartz. Single and multiple lines of interlocking quartz crystals are a constant feature. In a few instances, portions of the vein-filling consist of alternating layers of quartz and country rock. The latter, in such cases, is always heavily mineralized, usually with iron, and weathers to a rusty colour.

The list of metallic minerals contained in the veins as identified in the field, and in the laboratory of the Survey from specimens brought back by the writer, includes the following :—

Native Silver.—Occurs in small spangles and in wire form in the Montana and Uranus veins.

Argentite.—Is found in some of the veins but is not abundant.

Stephanite.—Occurs in several of the veins and is an important source of silver.

Freibergite.—A dark, highly argentiferous mineral occurring in some abundance in the Joe Petty, Montana, and some of the other claims has been referred tentatively to this species. A partial analysis by Mr. Connor showed it to contain copper, silver, zinc, arsenic, iron, sulphur and antimony, the constituents of freibergite. The copper percentage in the specimen examined amounted to 9 per cent and the silver to 37 per cent.

Pyrargyrite (Ruby Silver).—This rich silver mineral occurs in most of the veins, sometimes in considerable quantity.

Galena.—This mineral occurs in all the veins and is usually highly argentiferous.

Tetrahedrite.—Argentiferous tetrahedrite occurs in small quantities in the Montana, M. and M., and probably in other claims.

Chalcopyrite.—Occurs in the Silver Cliff and other claims east of Windy Arm.

Native Copper.—Occurs in the Millet, Fedora and other claims east of Windy Arm.

Malachite and Azurite.—Green and blue incrustations and stains referable to the copper carbonates and due to the leaching out of the copper in the tetrahedrite and freibergite occur in most of the veins.

Specimens of a green mineral stated to be a silver chloride proved on examination to be a copper carbonate. It is possible that such a chloride is present in some of the veins but it could not be detected in the specimens examined.

Iron Pyrite.—Common in all the veins.

Arsenopyrite.—Occurs in a number of the veins but is usually subordinate in quantity to the iron pyrite.

Pyrrhotite.—Occurs in the Big Thing group.

Sphalerite.—Zinc-blende occurs sparingly in most of the veins examined.

MINING DEVELOPMENT.

Montana.—This important vein is situated on a bleak hillside about 3,700 feet above Windy Arm and 5,860 feet above the sea. An aerial tramway, four miles in length, connecting it with Conrad City, on the lake shore, was nearly completed at the time of my visit. At present, all supplies and materials for the mine, including fire-wood, are packed on horses.

The principal workings consist of a drift 180 feet in length. The drift pierces 50 feet of slide rock, then meets and follows the vein. A small fault, with a displacement of seven feet, was encountered at one point. The strike of the vein is N. 43 W., and the dip 10 to 12 to the S.W. The width of the vein increases from about two feet near the mouth of the drift to nearly five feet at the face. Some stoping has been done and a considerable quantity of ore has been shipped.

The ore minerals include native silver, pyrargyrite, argentite, freibergite (?), tetrahedrite, galena, and iron and arsenical pyrites. The distribution of the minerals through the quartz gangue is somewhat irregular. In places, especially near the walls, the vein matter is so thoroughly impregnated with silver bearing minerals that it is rich enough to ship without much sorting—that is, it contains values of $80 per ton and over. The leaner portion of the vein will require concentration.

The principal values in the vein are in silver. The ferruginous portion of the vein is stated to also carry some values in gold.

At the time of my visit a second drift, intended to cut the Montana vein at a distance of 1,600 feet in a northwesterly direction from the main workings, was being driven, mostly through slide rock. The two workings are connected by a line of float ore and in places where the surface is bare by outcroppings ; the management were confident that the vein extended at least that far. Since leaving the camp the vein (or a vein stated to resemble the Montana vein in general character) is reported to have been struck.

Uranus.—The Uranus vein is situated just above the forks of Pooly creek, a small stream tributary to Windy Arm. It is distant from the Montana vein about a mile in a southerly direction, and from the lake about a mile and a half. The elevation above the lake is approximately 2,000 feet. The Uranus vein is traceable by numerous surface outcrops in a direction a few degrees east of south from the north to the south branch of Pooly creek, a distance of about 1,500 feet. The vein crosses a high ridge separating the two creeks and is thus exposed naturally in depth for some hundreds of feet. A tunnel starting at the south fork has been driven 180 feet along the vein, which dips to the west at an angle of about 40° and varies in width from a few inches to three or four feet. It carries considerable quantities of highly argentiferous galena and also some native silver, ruby silver and iron and arsenic sulphides. A few tons of sorted ore have been shipped.

Other important veins in the vicinity of Pooly creek and its branches are the Joe Petty and the M. and M. The Joe Petty is a very strong vein. A shaft following the lead has been sunk at one point to a depth of about fifty feet, showing a vein fully six feet in width. The vein material consists of alternating bands of quartz and silicified and mineralized country rock carrying layers and scattered grains and crystals of the rich silver and silver-bearing minerals of the district. The M. and M. is a much narrower vein seldom exceeeding twelve to fifteen inches in thickness, but is very persistent in strike. It is traceable on the surface for several hundred feet at least. This vein is especially rich in places in high grade silver minerals such as pyrargyrite, stephanite and the sulph-antimonite referred as freibergite.

Another important group of claims is situated south of Pooly creek and about half a mile west of Windy Arm. This group includes, among others, Venus No. 1, Venus No. 2, and Ruby Silver. No work was being done on them at the time of my visit. Venus No. 2, is an exceedingly strong vein. The only work done on it consists of two shallow openings about 400 feet apart. These show a vein fully nine feet in width. The vein-filling consists of three and nine inches of quartz along the foot wall, followed by alternating bands of quartz and decomposed and mineralized country rock. The ore is principally argentiferous galena. Good assays in gold are stated to have been obtained from this vein. Venus No. 1 is a smaller vein. A shaft following the vein has been sunk on it to a depth of fifty-two feet. This shows a quartz vein, increasing in width from ten inches at the surface to about thirty inches at the foot of the shaft, bordered by several feet of decomposed and mineralized country rock, fissured parallel to the vein. Fifteen tons of ore obtained in sinking the shaft and shipped to outside smelters are stated to have averaged $65 per ton in silver. Ruby Silver is a narrow siliceous vein spotted, in places, with the mineral from which it takes its name. Very little development work has been done on it.

South of the Venus group, and apparently in the same zone of fracturing, are the Red Deer and Humper Claims. The Humper vein, as shown in a couple of small openings, has a width of about two feet. The quartz is bordered above and below by about a foot of decomposed iron-stained country rock which might be considered part of the lead. A shaft twelve feet in depth has been sunk on the Humper Extension, an adjoining claim on the east. The vein followed has a width of about fifteen inches.

The ore on the dumps showed galena, ruby-silver, stephanite and green copper carbonate, probably derived from tetrahedrite.

About a mile north of the Montana is the Big Thing group. The conditions here are different, as the country rock is granite. A considerable body of loose ore, principally argentiferous galena, evidently derived from a strong vein, occurs on one of the claims. The vein had not been determined at the time of my visit. A number of other veins are reported to cross the various claims, but were not examined.

The claims briefly described above comprise only a small proportion of those staked in the district, but on most of the remainder little or no development work has so far been done, and the time at my disposal did not permit me to make a systematic examination of them.

The general outlook for the camp is considered exceedingly promising, and its opening up marks an important event in the mining history of the country.

The mining conditions are not unfavourable. Most of the veins are situated at distances of from half a mile to four miles from the lake and at elevations of from twelve hundred feet to three thousand six hundred feet above it. Aerial tramways can therefore easily be constructed for the carriage of the ores to the lake shore for concentration and can also be used to take supplies to the mines. Miners' wages during the past season amounted to $3.50 per day for eight hours work, and ordinary labourers obtained the same amount for ten hours work. The cost of supplies, considering the short distance to the seaboard, and the almost continuous rail connexion, ought to be moderate. The climate, while severe during a portion of the year, will have little effect on mining operations.

A Reconnaissance Survey on the Stewart River.

Mr. Joseph Keele.

I left Ottawa on March 25, with instructions to make an examination of that portion of the Stewart river above Fraser falls, and as many of its tributaries as time permitted. I reached Whitehorse on April 6, where some delay was occasioned owing to the non-arrival of canoes, and from this point, travelling partly on the ice and partly on the Yukon river, arrived at Dawson on May 18. Provisions for the whole season, and a camping outfit, were procured at Dawson, and, accompanied by two men, I embarked on the steamer "*Prospector*" on May 22, her first trip for the season up the Stewart river. We reached Fraser falls, a distance of 260 miles from Dawson, five days later. Here I was joined by a third man and the party was complete.

When we arrived at Fraser falls we found the Stewart river in flood and hourly increasing in volume owing to the unusually warm and early spring. The river reached its maximum height on May 31 and did not subside sufficiently to allow us to proceed in our canoes until June 7. During this period the water rose to a height of 25 feet above low-water mark at the head of the falls; it became extremely muddy, and a never-ceasing burden of floodwood and living trees torn from the banks was borne on its surface. This is the highest water which has occurred since 1898. The river afterwards rose on three occasions to a height of from 12 to 18 inches each time, the last rise being on July 3, and caused probably by the melting of snow on the higher peaks in the watershed ranges.

The only work previously done in this region was an exploratory topographic survey by Mr. J. J. McArthur as far as the mouth of Hess river, or South branch of the Stewart, in 1898. Consequently the greater portion of the season was devoted to making the necessary surveys for the preparation of a map.

A micrometer and compass survey was made from Mayo landing, a distance of 36 miles below Fraser falls, to a point 390 miles up the Stewart river; and for a distance of 45 miles up the Beaver river. Track surveys were made of the entire course of the Ladue river, and a portion of Rackla river. A good general idea of the relief of the region was obtained by a system of triangulation and sketches made with a small transit from several prominent mountain peaks. The surveys are now being plotted, and material will thus be furnished for an approximately correct map of a part of the country that, up to the present, has been almost entirely unknown.

The men who assisted me in the work are miners in the Duncan Creek district, who had an interest in the development of the country. They were highly efficient in every phase of the various duties assigned to them, and rendered excellent service.

The Stewart river above Fraser falls drains an area of about 120 miles in extent in an east and west direction, and about 80 miles north and south.

During its course through this area it receives four important tributaries, the principal one being Hess river or the South branch, which enters from the east at a distance of 55 miles from the foot of Fraser falls, following the windings of the river. Twenty-eight miles farther, Lansing river also enters from the east. Ladue river enters from the west at a distance of thirty-two miles above Lansing, and from the same direction Beaver river enters about seven miles above the mouth of the Ladue.

The headwaters of the Stewart river and its branches have their source either in the Ogilvie range to the north or in the Selwyn range to the east. These two mountain chains form the watershed between the Yukon and Mackenzie drainage basins in the region here described.

The entire drainage basin of the Stewart is of a mountainous character, and although much of the upland country of the area is composed of flat topped or gently rounded and wooded hills, there are high flanking ranges or single groups adjacent to the main ranges with peaks which measure from 6,000 to 7,500 feet above sea-level or almost as high as the most prominent peaks in the watershed ranges.

This mountainous region is traversed in several directions by a system of wide, interlocking valleys. The floors of these valleys are graded to as low a level as the character of the country will permit. Not all of them are now occupied by the river and its principal branches, although they all appear to be ancient drainage channels.

Evidences of a former glacial period are met with in various portions of the area. These consist of ice groovings and striae preserved on certain exposures of bed rock, the occurrence of drift at high altitudes, of boulder clay containing scratched and planed pebbles, and, above all, the characteristic topography which usually results from the smoothing action of a general ice sheet.

Until the observations made in the field have been laid down on the map, it will be impossible to give with precision any account of the geological features of the region. The rocks in general are closely analogous to those met with in the corresponding regions to the south and west.

The area between the Beaver river and the Stewart consists mostly of crystalline schists similar to those found in the Duncan Creek mining district, and described by the writer under the name of the Nasina Series in the Summary Report of the Geological Survey for 1904. These rocks appear to extend eastward up the Hess River valley, and are found in a few localities as far south as the MacMillan river. About ten miles below Lansing these schists are replaced by a series of rocks which are evidently much younger. These consist of dark carbonaceous and greenish argillites, and gray shales with occasional narrow bands of black limestone and sandstone hardened almost to quartzite. These rocks are exposed at intervals on the river banks as far as Beaver river.

Above the mouth of the Beaver river no rock appears on the river for a distance of forty-five miles, but beyond this point exposures are frequent. The rocks here consist of sandstones, grits, red and green slates and gray limestone. A section obtained on the bordering mountains to the south of the river shows a thickness of over 3,500 feet of these rocks. These rocks extend eastward for a considerable distance, and a similar series occurs on the MacMillan river.

North of the Stewart and Beaver rivers the mountains are composed principally of heavily bedded limestones and ferruginous slates. All these rocks are mostly of sedimentary origin with the exception of a portion of the crystalline schists, which are altered intrusives. Unaltered intrusive and volcanic rocks are also represented in this area, not, however, for any great extent, but occurring in small detached and irregularly distributed masses.

Several gold seekers entered this country during the Klondike excitement in 1898, but they do not appear to have done much prospecting. Those who passed down the Stewart river, while making the extraordinary journey from Edmonton, were intent on reaching Dawson as quickly as possible, and those who afterwards ascended the river devoted most of their time to hunting and trapping.

The portion of this region which, in the light of past experience, would seem to afford the most likely ground for the prospector in search of placer gold, is the area situated between the Beaver and Stewart rivers.

This area is mostly underlain by metamorphic schists, which are intruded in some places by igneous rocks, such as granite, diorite and diabase, and are similar in character to the bedrock in all the placer camps of the Yukon. Fine colours of gold were obtained in the gravels in many of the small streams along the route, but whether there was sufficient to pay for mining could only be determined by the usual methods of opening up bedrock.

In the area between Hess river and the Lansing river, east of the Stewart, at least three creeks flowing into these streams are said to yield coarse gold. This portion was not examined by the writer. On Congdon creek, which comes in from the east about ten miles below Lansing, good surface prospects were obtained by one of the party.

Above the mouth of Mayo river the gravel bars on the Stewart are only slightly auriferous and have never yielded wages to the bar miner. Beyond the mouth of Beaver river the bars do not appear to be auriferous; the same may be said of the Beaver river, and although fine gold was said to have been found in 1898 on the bars of Rackla river, its principal tributary, no colours could be raised by the writer's party in that stream.

About one mile up, on a small creek nearly opposite the mouth of Rackla river, a small quantity of coarse gold was obtained in the surface gravels.

No gold-bearing quartz has, so far, been discovered in this region. Small bodies and stringers of vein quartz are of common enough occurrence in the area of metamorphic schists, but none which contained gold were seen on the portion of the area traversed.

A large body of quartz, in low, rugged ridges, crosses the Stewart valley about ten miles above Hess river, and a similar body occurs on Rackla river below the forks. Both are apparently barren of any mineralization.

There is a small band of native inhabitants living in cabins at the mouth of Lansing river, at which point Messrs. Frank Braine and Percival Nash have established a trading post. A number of Indians from Fort Good Hope on the Mackenzie river make a yearly journey to Lansing, hunting and trapping over the intervening country during the trip. A few white men also make a business of trapping; these confine their operations mostly to the country in the vicinity of Hess river. The principal land quadrupeds are the moose, caribou, mountain sheep, brown and black bear, wolverine, martin, wolf, lynx, fox, marmot, rabbit, beaver, mink and muskrat.

There is an abundance of fish in the rivers and lakes, such as salmon trout, white-fish, pike and grayling. The king salmon, coming up from the sea to spawn, were observed high up in the Beaver river, and several are caught at Lansing. These were the more vigorous ones, as the majority of the salmon are unable to ascend the Fraser falls.

The Stewart river opened and became free from ice at Lansing on May 10th. There was no frost between May 24th and August 23rd, and during this period the weather was very fine and warm. The snow disappeared almost entirely from the mountain ranges, and only a few of the highest peaks retained any on the first of August.

It was an exceedingly fruitful year in this locality. There was a great profusion of all the native wild fruit, such as blueberries, raspberries and red and black currants.

A garden planted by Mr. Braine near his house at Lansing produced very fine vegetables. All the varieties found in the gardens in the vicinity of Dawson can be grown here.

PEEL RIVER, IN THE YUKON AND MACKENZIE DISTRICTS.

Mr. Charles Camsell.

The field work assigned to me for the season of 1904 embraced a geologic and topographic reconnaissance of the Peel river, in the extreme northwestern portion of the Dominion. The inaccessibleness of the region, and the shortness of the season, necessitated an early start, and, in accordance with instructions received, I left Ottawa for Winnipeg about the middle of March. At Winnipeg supplies were purchased and shipped through the Hudson's Bay Company to meet me at Fort Macpherson in August, and later I proceeded to Dawson, where I arrived on the 14th of April.

At Dawson the interval between the closing of winter travel and the opening of navigation on the streams was consumed in the testing of instruments and in visiting and examining the placer mines of the Klondike creeks. During this period I was deeply indebted to Mr. J. B. Tyrrell for much kindness and hospitality. To Major Wood, also, Commandant of the Royal North-west Mounted Police in the Yukon, are my thanks due for assistance.

On May 22nd the party, consisting of six men with three canoes, left Dawson by ss. *Prospector* for Fraser falls on the Stewart river, which was not reached uutil the 26th. Another delay, occasioned by an early rise of water in the Stewart, prevented us from moving until June 5th. When a start was finally made, it was only with the greatest difficulty and some danger that any progress could be made. The velocity of the current occasioned large quantities of driftwood, and in many places the banks were completely submerged. Under these conditions we were eight days in getting as far as Lansing creek, a distance of eighty miles. Above Lansing creek the water gradually subsided and the travelling was much easier until we came within a few miles of where the actual survey was commenced.

At the mouth of Braine creek, a tributary of the Beaver river, the micrometer survey was begun, though a track survey was carried up from Williams' cabin at the cañon seven miles below, to connect with Mr. Keele's survey of the lower part of Beaver river.

It was my original intention on leaving Ottawa to follow identically the same route across the mountains as was taken by the prospectors in 1899, but I was dissuaded from this, on reaching Dawson, where I was informed that any other route would be preferable. Though I could not learn that anyone had ever taken a canoe across into Peel river waters by any other route than the Bonnet Plume pass, I did learn that Indians had come across from the Wind river to the Beaver river through a pass that was said to be very much lower than the Bonnet Plume. It was finally decided to find, if possible, this winter route, and follow it.

In ascending the Stewart river, we met Mr. Braine of Lansing creek, and from him obtained the necessary information as to how to find the pass to the Wind river. The Braine pass—the name I have adopted for this new route—though an easy winter route, is not a feasible one for canoes. Though we went through at a time when the water in Braine creek was probably at its best stage, we had to portage almost the entire route for fifteen and a half miles, of which distance the canoes were carried for three and a half miles.

A micrometer and compass survey was carried from the mouth of Braine creek through Braine pass, and down Nash creek to the Wind river, a distance of thirty miles.

From the mouth of Nash creek to the Peel river the course of the stream is almost true north; to save time, a careful track survey, checked by frequent observations for latitude, was all that was made. This distance is approximately one hundred miles.

We reached the Peel river on the 13th of July, and from this point a micrometer survey was recommenced and carried down the stream to a point ninety-eight miles below Fort Macpherson, where the western branch of the river first joins Mackenzie waters; from this point back again to Fort Macpherson by the central branch of the Peel river. The survey of this portion was completed on the 11th of August, and on the 15th the return journey to Dawson was begun. Altogether, 335 miles of micrometer survey, and 275 miles of track survey, were made on Peel river waters.

Returning, the route followed was that by the Rat river, through Macdougal pass, and into the Bell and Porcupine rivers, the same as that taken by Mr. W. Ogilvie in 1887. A small portion of new work was here done in surveying the central and largest outlet of the Rat river—the south branch, which was surveyed by Mr. Ogilvie, being impossible except in the spring. The Rat river empties by three branches into the Peel river, but the northern branch is an inconsiderable stream and only navigable in high water, so that no attempt was made to map it. In the ascent of Rat river we were particularly fortunate in having a great deal of rain and snow, which raised the level of the water sufficiently in the stream to allow of comparatively easy canoeing. The same conditions allowed us to get our canoes within 600 yards of navigable waters on the western side of the summit, a portage of that length being all that was necessary across the Mackenzie-Yukon divide at this point. Had we been a week or two earlier, or a few days later, we would probably have been compelled to make a portage of three or four miles in length.

The Porcupine river was followed down to its junction with the Yukon river at Fort Yukon, where we arrived on September the 8th, the actual travelling time from Fort Macpherson to Fort Yukon being twenty days. A track survey was carried all the way from Fort Macpherson to the boundary line of Alaska just below Rampart House, where it was closed.

After a delay of five days at Fort Yukon. we caught a fast steamer plying between St. Michaels and Dawson, and arrived in Dawson on the 17th of September.

DESCRIPTION OF ROUTES.

Braine creek is a typical mountain stream, never in any part navigable for canoes. From its source—in two small mountain glaciers on the flanks of one of the highest peaks in the region—to its mouth is a distance of sixteen and a half miles. It has a general direction of S. 35 W., cutting almost directly across the strike of the rocks. The stream occupies a broad U-shaped valley, sometimes a mile in width, with the bordering mountains rising to a height of 3,000 feet on either side. The grade is always exceedingly steep and the volume of water is never very great.

Two cañons occur in the creek. The lower one—two miles from the Beaver river—is deep and narrow and about two-thirds of a mile in length. The second lies four and a half miles above the first, and is about three hundred yards long with a fall of about twenty-five feet.

Immediately above each of these cañons the bed of the stream expands and is almost entirely filled with sheets of ice, through which the water cuts narrow, winding channels. These ice sheets are probably formed during the winter. A great many of the small tributaries of Braine creek are fed from springs in the limestone, and these probably maintain a continuous outflow throughout the year, so that even in the coldest weather there must be a certain quantity of water flowing down the creek, thus accounting for the formation of the ice sheet.

Fourteen miles up, the stream divides, and to this point the canoes were dragged. Immediately below this point the valley is occupied by several small marshy ponds, among which the stream meanders with only a slight grade.

At the forks of the creek the valley divides, forming two passes, each of which brings one in a few miles into Peel river waters. Though the eastern pass is 200 feet lower than the western, the latter was selected as our portage route because it brought us into a much larger and more navigable stream than the other; but the eastern pass is the more direct route to the Wind river. Each of these passes is wide and open. A scrubby growth of willows and alders fills the bottoms of the valleys, while the sides are fringed with a scattered growth of spruce trees, which extend only a short distance up the slopes of the bordering mountains.

The elevation of the summit of the western pass is estimated at three thousand three hundred feet above sea level. From the forks of Braine creek to this summit there is a long gradual ascent of 350 feet, with a much steeper descent of 400 feet on the other side of the divide to the bed of Nash creek. The greatest elevation of the highest peaks in the neighbourhood of the pass is scarcely 7,000 feet.

Nash creek is considerably larger and longer than Braine creek. It has its source in a large lake, and its total length is about twenty-five miles. The upper half of its valley is very wide and is a continuation of the broad structural valley of the two arms of Braine pass. The lower half is narrower and more V-shaped, and inclined at a slight angle to the upper half. One mile above the portage Nash creek forks, the smaller branch also rising in a lake five miles beyond. The two branches, however, each occupy a part of the same wide valley, and are only separated from each other by a long narrow ridge fifteen hundred feet above the bed of the stream. The grade of Nash creek is very steep, and though only one short cañon occurs, the rest of the stream is very swift and shallow and full of gravel bars. It is often bordered by cut banks of consolidated clay and gravel, which have a height of a hundred feet and more. From the north end of the portage trail to the junction with Wind river is a distance of twelve miles. The creek, however, enters the Wind valley nine miles below the portage, and flows in it for three miles before joining with the waters of the Wind river.

The vegetation on Nash creek is slightly different from that on Braine creek. Balsam, poplar and spruce grow in abundance on the flats of Nash creek, while none of the former tree was seen on Braine creek.

Topographically, the country between the Beaver river and the Wind river is one of rather rugged relief. Few prominent peaks occur, and from the top of any one of them a general accordance of level can be noticed. This general level gives an average vertical relief of about 3,000 feet, with a few peaks rising perhaps 500 feet above this.

The great wide valleys are longitudinal valleys, coinciding with the strike of the rocks, and these are joined by narrower and shorter transverse valleys. These great valleys have a general east and west trend, showing that their formation was due to pressure from the north and south.

During the glacial period the valleys alone were filled to a depth of 1,000 to 1,500 feet with glaciers, which, apparently, moved along the present grade of the streams. Evidence of glaciation can be traced to a height of about 4,500 feet above sea level, so that about 2,000 feet or more of the highest peaks protruded through the ice. The limit of glaciation corresponds fairly closely to the timber line, and is well shown by the rounded and graded appearance of the slopes and shoulders up to that point.

In the gradual retreat of the glacier up the valley of Braine creek, it evidently halted sufficiently long at each of the two cañons to allow of the formation of extensive terminal moraines. On the disappearance of the glaciers, the valleys of both Braine and Nash creeks were filled to a depth of, sometimes, 150 feet, with a heavy deposit of boulders, gravel and clay, the ground moraine of the valley glaciers, which was later subjected to deep dissection by the present streams. At present only a few small cirque glaciers exist, and these only on the northern sides of the mountains, where they are protected from exposure to the rays of the sun.

A section across the summit from the Beaver river to the Wind river shows a series of closely folded and sometimes faulted limestones and slates with some quartzite and conglomerate. Cutting these are diabase dikes and intrusive rocks. The succession in descending order is somewhat as follows :—Massive limestone becoming shaly at the base ; bands of black slate ; massive granular limestone containing fossils ; ferruginous slates weathering red ; dark conglomerate at the base. Remnants of a coarsely crystalized quartzite at the top of the series sometimes form the peaks of the higher mountains These strike as a rule from west to northwest, and dip at various angles, forming a succession of synclines and anticlines. The appearance of the ferruginous slates is a noticeable feature in the topography of the region in the neighbourhood of Wind river, for the slopes take on a dull reddish colour due to the oxidation of the iron in the slates.

Favosites, *Productella* and *Atrypa Reticularis* were obtained from the limestones at the summit and are probably Devonian forms.

With the exception of some limonite in the rocks at the pass, no indications of economic minerals occur. While a few small colours of gold were obtained on the Beaver river, these disappear entirely on Braine and Nash creeks.

The Wind river from Bonnet Plume pass to the Peel river has an estimated length of 132 miles. Nash creek enters it about thirty miles below this pass. It has a general direction of almost true north, and continues to flow for about forty miles below Nash creek through the mountains before entering the plateau region of the Peel river. In this section the stream occupies a broad U-shaped valley, timbered in some parts by spruce and poplar, but totally bare in others. In this the river flows in a broad shallow bed sometimes half a mile wide. When confined to one channel, the breadth of the stream, before its junction with Nash creek, is 100 feet. The sides of the valley decrease in height from 3,000 feet at Nash creek to about 2,000 feet at the northern edge of the mountains. In several expansions of the river bed large sheets of ice were still remaining at the beginning of July, similar to those occurring on Braine creek.

On leaving the mountains, the river emerges at once on to a rolling country of foot hills, later replaced by a perfectly level, wooded plateau, which extends northward practically to the delta of the Mackenzie river. The mountains present a rather abrupt face to the lower country, and appear to be unbroken by any great valleys except that of the Bonnet Plume river to the east. West of the Wind river they stretch away to the Little Wind river, beyond which they swing around to the north, and cross the Peel river near the mouth of Hart river, thus forming a great semi-circular basin inclosing the lower parts of the Wind and Bonnet Plume rivers, and in which a few outliers of the mountain range break the level of the region, rising to a height of about 2,000 feet.

The character of the stream in the foothills section is very uniform. With the exception of a short portion where it cuts through the Illtyd range of mountains and approaches the nature of a cañon, the bed is usually wide, shallow and filled with gravel bars. Few rock exposures occur, and the stream flows with a varying rate of from four to eight miles an hour.

The principal feeders flowing into the Wind river are the Bear river from the east, and the Little Wind and Hungry creek from the west. Of these the Little Wind river has a volume of water equal to about two-thirds of that of the main stream.

The topography of the mountain section of the Wind river resembles that given for the summit portion. The relief varies with the texture and hardness of the rock. The most noticeable feature is the abruptness with which the range rises from the floor of the plateau in the portion east of the Wind river. West of this—where the range swings around in a curve to the north—it is bordered and flanked by lower ranges of foot hills, which make a gradual slope eastward down to the level of the plateau.

The foot-hill ranges are usually low, rounded hills, seldom more than 2,000 feet in height, and more often less than 1,000. Their origin is due to the same orographic movement in the earth's crust which resulted in the upheaval of the Ogilvie range. The majority of them are anticlinal in structure ; but several smaller hills are due to faulting on a large scale. They extend northward beyond the Peel river and eastward to the Snake river. Almost in the centre of this area is a large low lying basin, covering over five hundred square miles, and occupied by scarcely disturbed Tertiary rocks. This basin is almost completely inclosed by the encircling foot-hills, and lies between the Wind and Bonnet Plume rivers, extending southward some fifty miles from the Peel river.

As in the summit section, the Wind river valley—as well as other valleys in the neighbourhood—was occupied by valley glaciers, filling them to a depth of fifteen hundred feet or more. These glaciers, on leaving the mountains and entering the rolling country, spread over the whole plateau, covering the surface with a variable thickness of boulder clay and smoothing and rounding off the tops of the foot-hills that did not attain a sufficient elevation to protrude through the ice sheet.

Existing glaciers were seen only on the flanks of the high mountains opposite the mouth of Nash creek ; but that others have existed in other portions of the Wind River valley is proved by the presence of some basin-shaped cirques, particularly on the west side of the valley.

The rocks of the mountain section of the Wind river consist of ferruginous slates, limestones and sandstone which alter to crystalline limestones and quartzites, with some conglomerate. These strike nearly at right angles to the course of the stream, and dip at all angles, being tilted into a series of anticlines and synclines. Near Bear river the sandstone forms some of the higher peaks in the region, and shows the characteristic weathering of this kind of rock in being eroded into all sorts of fantastic shapes. Sharp pinnacles and columns of rocks and steep precipices are noticeable features wherever this sandstone occurs. Alluvial fans, too, are common.

A great quantity of iron ore float occurs in the drift of Bear river. The same float also occurs in large quantities on the Bonnet Plume and Snake rivers. Only very fine colours of gold were found in the gravels of the Wind river.

On leaving the main range of mountains the geology changes immediately. Though the rocks of the Illtyd range of mountains and of Mount Deception are dolomitic limestones, probably of the same age as the rocks of the main range, these are completely surrounded by almost undisturbed Cretaceous rocks, well exposed on the streams about ten miles above the mouth of the Little Wind river. They consist of sandstone of soft texture, and conglomerate containing ironstone nodules and some fossil wood. This Cretaceous area extends northward along the Wind river to a point a few miles below Mount Deception. It is then replaced by more recent rocks of Tertiary age, through which the river flows down to a point one mile from the Peel river. The contact below Mount Deception is covered with drift, but is well shown near the Peel river, where the soft sandstone and lignites of the Tertiary basin are seen to rest unconformably on the upturned and truncated edges of some black slates. This section shows forty feet of boulder clay resting unconformably on fifty feet of soft sandstone, with which is interstratified eight thin seams of lignite. These rest with an unconformity on the rusty black slates. Higher up the stream one seam of lignite, six or seven feet thick, is exposed on the west bank of the stream ; but the lignite is still in a primary stage of development and shows the twigs, leaves and moss of which it is composed, and even some blebs of resin. The lignite, when dry, burns fairly readily, giving off an odour of burning resin, and leaving much ash.

Colours of gold were obtained on the Little Wind river and on Hungry creek. Prospectors are said to have found coarse gold on the latter stream, but time did not permit us to verify this report.

The Peel River.

The Wind river enters the Peel river one mile above the lower end of the upper cañon, or 201 miles above Fort Macpherson. Above this, the stream was not explored, but the cañon is said to extend up to the Aberdeen falls, an estimated distance of about thirty miles. The cañon is cut to a depth of 150 feet in hard black slates, and its average width is about 500 feet. The river, here, has a velocity of from four to seven miles an hour, and is apparently easily navigable for canoes. Water marks stand at a height of twenty-five feet above the normal level, and when the stream is at this stage the cañon would be impassable.

After leaving the cañon the stream flows eastward for fifteen miles through the low level Tertiary basin, when it enters the lower cañon, just above which the Bonnet Plume river enters from the south, discharging a volume of water slightly greater than that of Wind river. Nearly opposite the mouth of the Bonnet Plume, Mountain creek enters from the north and it is this stream that the Indians ascend in making their winter portage across the great bend in the Peel river.

The lower cañon is formed by the stream cutting a deep and narrow defile through the low range of hills bordering the Tertiary basin on the east side. The walls of this cañon are almost vertical and rise to a height of about 500 feet, giving an erroneous impression of dangerous navigation.

The course of the stream below the lower cañon is still easterly for thirty-eight miles, or as far as Snake river, from which point it turns off almost at right angles to its former course and flows northerly. In this section the stream has a velocity of from four to eight miles an hour. Swinging from one side of the valley to the other, it cuts deeply into the soft shales and sandstones of which the plateau is built, forming steep cut banks, which are constantly dropping blocks and fragments into the rushing stream below. The banks of the valley at the cañon are 500 feet in height, and from this point down to within thirty miles of Fort Macpherson the stream flows through the high Peel plateau, cutting a deeper and deeper valley northward till the banks attain a maximum height of 1,000 feet. The plateau is level or gently undulating, carrying on its surface several muskeg lakes. It is usually forested, and covered with moss, a few inches below which the ground is frozen during the whole year.

The Snake river, sometimes called the Good Hope river, enters the Peel river in the corner of the large elbow that the latter makes. It was originally supposed to be the main stream, but an estimate of its discharge, taken about the middle of July, shows the Peel river to be about four times as large. It was explored for a distance of about twenty-five miles, but from the summit of one of the neighbouring hills, its course through the plateau could be traced for about fifty miles, flowing in a northwesterly direction from near the eastern border of the Ogilvie range. It has a velocity of four or five miles an hour, and occupies a valley about 700 feet deep and half a mile wide.

From the Snake river to Fort Macpherson is a distance of 147 miles, and in this section there is little variation in the general character of the stream. The valley has an average width of one mile, the greater part of which is taken up with gravel-bars and wooded flats, and it is bounded by banks of clay, sandstone and shale which vary in height from 600 to 1,000 feet. The average velocity of the current gradually decreases northward, and though it frequently attains a speed of eight miles an hour, as we approach Fort Macpherson it drops to two miles an hour.

Few streams of any consequence enter the Peel river below Snake river. As the course of the stream is parallel to that of the Arctic Red river, which lies to the east at a distance of only thirty or forty miles, no large streams could be expected to enter from this side. Of the smaller tributaries the most important are George river and Satahs river, and two others, which are nameless, of almost equal volume. These drain the level lake country on the top of the plateau. George river, thirty-two miles below the Snake river, is a very small stream about forty feet wide; while Satahs river sixty-two miles below this, has a width of 120 feet. The other two streams entering from the east each have a width of about 100 feet with a very sluggish current.

The Peel river has a much larger area to drain on the west side, and naturally receives more water than from the east. The principal streams entering from the west are Cariboo creek, Trail creek, Road river and Stony creek, all of which have very steep grades and draw their water from the range of mountains that runs parallel to, and about 25 miles west of the Peel river. They all occupy rather wide valleys that are cut deeply into the high plateau, and none of them are navigable for canoes. Road river, twenty-four miles above Fort Macpherson, is the largest tributary below Snake river, and has a width of about 100 yards. Trail creek is the stream which the natives ascend in making their winter portage across country to the mouth of the Bonnet Plume river.

At Satahs river the Peel river emerges from the high plateau, and enters what is probably the coastal plain. The transition from the one to the other is very abrupt, and the escarpment of the plateau is about 700 feet high. The face of this escarpment has a semi-circular shape, the western arm of which has a maximum elevation of 1,000 feet, while on the east side this level decreases gradually to about 400 feet. The stream skirts along the eastern face of the western arm of this plateau escarpment, sometimes cutting through projecting points or outliers of it, until, as we approach Fort Macpherson, it leaves it altogether. Fort Macpherson itself stands on one of the outliers or remnants of the plateau, and there are numerous others to the east.

Fort Macpherson consists of the Hudson's Bay Company's establishment, a Church of England mission and a small detachment of the North-west Mounted Police.

Below Fort Macpherson the Peel river enters the flood plain of the Mackenzie delta, in which all, or nearly all, the land is submerged in the spring floods. The southern edge of this delta is a line drawn from the Fort to Point Separation, and marked by several low ridges, similar to the one on which the Fort stands. From Point Separation the trend of the higher land is northward, skirting along the east side of the eastern channel of the Mackenzie, and culminating in a low range called the Reindeer hills, below Campbell river. West of the Peel river the margin of the delta is the eastern face of the high escarpment mentioned before, which trends slightly west of north from Fort Macpherson, crossing the Rat river below the mouth of Long Stick creek and gradually approaching the mountains west of it until it merges with them and disappears at the base of Mount Goodenough. The boundary of the delta north of this is then the base of the mountain range.

Twelve miles below Fort Macpherson the Peel river divides, the eastern channel joining the Mackenzie river by two mouths twelve miles below. The western channel, which locally goes by the name of the Huskie river, follows along the western edge of the delta and does not join the Mackenzie waters until ninety miles below. Between these two channels are several smaller channels of the Peel river, and these, with the Mackenzie river channels, form a network of streams which would take years to thoroughly survey.

The delta of the Mackenzie and Peel rivers covers a very large area, 100 miles from north to south, with a width of about 70 miles in its broadest part. Besides the streams which ramify through it, the most striking feature is the number of lakes that cover its surface everywhere. One can only get an idea of the quantity by looking over the delta from one of the mountains to the west of it. It is heavily wooded with spruce as far as latitude 68° 30', where this tree gradually dies out and only willows and alders remain. These extend northward nearly to the sea, where the more recently formed land is entirely devoid of any vegetation.

The few facts observed with regard to the glaciation of the plateau section of the Peel river point to a northward movement of the ice. According to McConnell's theory the ice from the Archaean gathering ground to the east of the Mackenzie river poured westward through the gaps in the mountains to the east of the river, until it reached the main axial range, and was then deflected to the northeast down the valley of the Mackenzie to the sea. From the mountains to the west only large valley glaciers from 1,500 to 1,800 feet in depth issued from the valleys, and spread over the surface of the plateau, moving slowly northward and perhaps slightly eastward, till they met and merged with the northwestward moving sheet of ice from the Archaean highlands to the east.

On account of the softness of the rocks and the universal covering of moss, glacial striæ are never seen on the plateau itself. On the south side of Mount Goodenough at an elevation of 1,500 feet, grooves and scourings which may be due to glacial action were noticed on a saddle backed ridge. These have a bearing of N. 20° W., but whether caused by a small mountain glacier or by the large ice sheet, it is difficult to say. No existing glaciers were seen in that region. Unmistakeable evidence, however, was obtained that a mountain glacier had existed on the western face of Mount Goodenough.

The rocks of both the upper and lower cañons of the Peel river consist of a series of closely folded black slates, with some bituminous limestone. The strata have been much crushed and crumpled and many faults appear, while the rock itself has been greatly sheared and brecciated. The texture of the slates is very fine-grained, but it contains some crystals of pyrite disseminated through it, and some bituminous matter. These slates contain no fossils, but from their lithological resemblance to some bituminous shales and limestones on the Mackenzie river, they have been tentatively referred to the Devonian period.

The rocks of the Tertiary basin lying between the two cañons consist of soft sandstone, with some thin seams of lignite, overlaid by more sandstones with pebbles, with clay and some very thick beds of lignite. One bed of lignite near the top of the series is thirty feet in thickness and fairly persistent, appearing in two exposures four miles apart with a shallow syncline between. Associated with this, and somewhat below it, is another seam eight feet in thickness. The lignite has been ignited by some cause and portions of it are now burning. Great landslides and patches of reddened shales in other sections of the valley indicate places from which the lignite has been consumed. These beds, like similar beds on the Mackenzie river at the mouth of Bear river are now burning, and have been burning for a great many years.

The geology of the Peel river below the cañon is simple, and sections of it are always exposed on the valley banks. The strata have been folded into a series of long and gentle undulations, which strike almost north and south, parallel to the bordering mountain range. A section five miles below the cañon shows about 200 feet of yellow and red shales, resting on massive sandstone 100 feet thick. Underneath is about 150 feet of rusty pyritous shales, very fissile. Overlying all is the glacial drift with a depth of about forty feet.

On the Snake river the rocks consist entirely of soft gray argillaceous sandstones, and in the low range of mountains on the west side of the river these same sandstones become slightly indurated, approaching the nature of a quartzite.

Below Snake river the Peel river follows the strike of the gentle undulations of the plateau, so that there is little variation in the character of the rocks. Argillaceous sandstones with beds of clay merge gradually into sections in which the clay occupies a much larger proportion or changes to shale. In places the sandstone is c ncretionary or contains the peculiar pressure figures known as "cone-in-cone."

A few miles above George river is the "Alum hill" of the early explorers, where some epsomite has been leached out and deposited as a crust on the clay of the river bank.

On leaving the plateau at Satahs river only sandstones and conglomerate are exposed in the cliffs of the river banks. These sandstones are very fossiliferous, some of the beds being made up almost entirely of fossils of a variety of *Tellinidae.*

Fossils were obtained in several parts of the Peel river from Snake river down to Fort Macpherson, and all are referable to the Cretaceous period.

Below Fort Macpherson only alluvial sands and clays are exposed on the river banks, and these are being built up and added to year by year when the streams are in flood and inundate the whole delta.

The mountain range to the west of the delta, which attains an elevation of more than 3,000 feet, is built up of slightly folded strata, and is characterized by flat or gently rounded summits. At the base is a thick series of black shales, which towards the top contain beds of hard gray ironstone. These latter weather red and are conspicuous along the face of the mountain. The shales are replaced upwards by argillaceous sandstones and these again by siliceous sandstones. The latter become metamorphosed to quartzites and constitute the upper members of the series. These strata are persistent westward up the Rat river and to the other side of the divide, and, from their fossils, are also referable to the Cretaceous period.

Placer gold does not occur on the Peel river below the Wind river, and the only products of economic interests in the rocks are the beds of lignite, some bituminous coal, epsomite and perhaps petroleum.

Rough estimates were made of the discharges of some of the streams and the following results were obtained :—

Wind river on July 14th	5,402 cubic feet per second.		
Snake river on July 20th	6,960	"	"
Peel river at Fort Macpherson on July 31st..	49,206	"	"
Peel river above Wind river on July 14th...	15,136	"	"

The Bonnet Plume River is as large if not larger than the Snake river.

THE UNUK RIVER MINING REGION OF BRITISH COLUMBIA.

Fred Eugene Wright.

INTRODUCTION.

The occurrence of valuable ore deposits and placer gold near the headwaters of Unuk river, British Columbia, has been known in a vague way for many years and during the past two seasons definite steps have been taken to develop its resources systematically. Interest has been shown by prospectors and miners, not alone in this locality, but also in the entire mineral belt situated along the eastern flank of the Coast Range granite and not far distant from the International Boundary line. Discoveries of ore bodies, which appear to warrant careful investigation, have been made at several points in this zone recently, notably near the head of Portland canal, also up Unuk and Stikine rivers, and farther north near Caribou Crossing. From a geologic and economic standpoint, these regions are practically unknown and, with the exception of brief notes by Dawson (*a*) and Brooks (*b*), have not been described in detail.

(*a*) Dawson, G. M., The Yukon District, N.W.T. Geol. Nat. Hist. Survey, Canada, new series, Vol. III., Pt. I.. 1887-1888 B.
Report on an Exploration from Port Simpson on the Pacific coast to Edmonton on the Saskatchewan, embracing a portion of the northern part of British Columbia and the Peace River country. Geol. Nat. Hist. Survey, Canada, 1879-1880 B.

(*b*) Brooks, A. H., Preliminary Report on the Ketchikan Mining District. Prof. Paper No. 1, U.S. Geol.Survey, 1901.

In September, 1905, the writer made a hasty reconnaissance trip to one of the localities by way of Behm canal for the purpose of examining its prospects and collecting data of geologic interest. He is much indebted to Mr. J. W. Daily, manager of the Unuk River Company, for many courtesies extended which aided greatly in furthering the investigation. During the past year the International Boundary line has been permanently established by the Commission and the uncertainty which has heretofore existed as to its exact position, thus removed.

GEOGRAPHY.

Unuk (or "Junuch" = "Dream," in the language of the Tlingit Indians) river is one of the four large transmontane streams which rise in British Columbia either beyond, or well within the Coast Range, and crossing the International Boundary line, enter tide water on the Alaskan coast. Unuk river is about 54 miles in length, and with its tributaries drains the Pacific side of the Coast Range divide between Stikine river on the north, and Portland canal on the south. At its mouth the river has formed a wide delta deposit which is gradually filling Burroughs bay, a deep water indentation adjoining Behm canal, about 60 miles northeast of Ketchikan, Revillagigedo island, Southeastern Alaska. The river is swift and too shallow to permit river transportation on a large scale, and is furthermore obstructed by three cañons which can be passed only during periods of low water and then by canoes or small boats alone.

At its source a narrow divide leads over to a branch of Iskoot river along which prospectors can pass and enter the rolling plateau lands of British Columbia. This natural entrance from the coast into British Columbia has long been known and would have been used many years ago had the natural obstacles at the start on Unuk river been less formidable. Within the past three years, however, these conditions have been improved by the construction of a wagon road from the mouth of Unuk river to a prospect 42 miles inland. The road is at present twenty-five miles in length and when completed will furnish easy access into the mineral belt and thus increase its value materially.

The fiord-like valley of Unuk river is bounded by steep glaciated mountains 4,000 to 10,000 feet high, frequently rising sheer from its valley floor. It has been shown by Messrs. Spencer and Brooks (a) of the U.S. Geological Survey that the large rivers which traverse the Coast Range are probably antecedent in character and have preserved their original drainage courses during the mountain uplift.

In glacial times the ice streams followed these same lines, scouring them thoroughly and even making deep incisions into the country rock itself, so that at present the land forms are those of an intensely glaciated region. The usual features of glaciation—U-shaped valleys, hanging valleys, glacial terraces, rounded mountain tops, glacial erratics, flutings and grooves—abound and show by their freshness that only a small amount of erosion has been accomplished since the glacial epoch. On several of the mountain slopes the work of ice erosion is still being continued by small ice streams, the

(a) Spencer, A. C., Pacific Mountain System in British Columbia and Alaska: Bull. Geol. Soc. Amer., Vol. 14, pp. 117-132.
Brooks, A.H., Ketchikan Mining District, Prof. Paper, No. 1. U.S. Geol. Survey.

last remnants of the huge ice sheets which formerly covered this entire area to a depth of over 6,000 feet.

Along the banks of Unuk river timber of good quality occurs in occasional patches and consists chiefly of spruce, hemlock, cedar, cottonwood, with some balsam fir trees near its head. Trees of spruce and hemlock, four to six feet in diameter, are not uncommon and are reported by lumbermen to be of fair quality. The quantity and supply of timber are sufficient to supply mining purposes for many years. The underbrush is dense and, together with the wet climate and the malevolent Devil's club *(Echinopanax horridum)*, add to the difficulties to be overcome by the prospector.

GEOLOGY.

The geologic section exposed by the deep Unuk River cut, affords an unusual opportunity for the study of the Coast Range from many different view points. In a broad way its consideration may be resolved into a study of the intrusive Coast Range granite and the adjoining belts of altered sedimentary rocks on the east and west.

The Coast Range granite belt, which is traversed by Unuk river, is a small part of an immense granite batholite (*a*) nearly 1,000 miles in length and 30 to 60 miles in width which extends from Fraser river to British Columbia in a northwesterly direction, parallel to the coast, to the White river basin in the Yukon district. The Coast Range granite is one of the master features of the geology of this entire coastal strip and deserves careful study, not only by the geologist, but also by the prospector, since the major portion of the ore bodies which have been discovered probably have a genetic relation to the intrusive granite (*b*). From evidence obtained at other points it has been shown that the intrusion of the Coast Range granite took place between Upper Jurassic and Middle Cretaceous times.

Petrographically the field term, granite, applies to only a small part of the intrusive rock types. The prevalent type is less siliceous and ranges from grano-diorite to diorite and gabbro in composition with hornblende and biotite as coloured constituents and titanite as a frequent accessory component. As a general rule hornblende appears to be more abundant near the coast, while biotite predominates near the inland border of the batholite. Near the coast the granite is also more noticeably gneissoid in aspect and contains abundant inclusions of the intruded schists near its contact. These inclusions become more and more coarsely crystalline as the contact recedes until finally they resemble basic or acid differentiation products and are gradually lost sight of. It is a characteristic feature that while aplitic and particularly pegmatitic dikes are extremely abundant near the western contact of the granite and form an intricate network in the adjoining schist areas, they are rare and practically absent in the central parts of the massif. On its eastern flanks acid dikes occur frequently but are far less abundant than on the coastal side. The absence of minette and similar basic differentiation dike products is noteworthy and may be due to the fact that the acid dikes are pegmatic rather

(*a*) See Geologic Map of the Dominion of Canada, Western sheet, No. 783. Edition of 1901.
(*b*) Spencer, A. C., the magnetic origin of vein forming waters in Southeastern Alaska. Trans. A. I. M. E., Vol. XXXVI., pp. 971-978.
Brooks, A. H., Ketchikan Mining District. Prof. Paper No. I., U. S. Geol. Survey, 1901.

than aplitic in character and therefore are not, strictly speaking, differentation products.

The importance of the pegmatites becomes apparent when their mode of formation from solutions emanating from the intrusive mass is considered. They represent only a small part of the work accomplished by the pneumatolytic solutions of the granite and are a silent but convincing witness of the great volume of pneumatolytic solutions which accompanied the batholitic intrusion. The intimate connexion of ore bodies in south-eastern Alaska with the intrusive masses has been proved directly in several instances and is inferred in a number of the remaining deposits.

Considered as a whole, the Coast Range granite has not produced the ordinary type of contact metamorphism in the rocks which it intrudes. On approaching its western contact from the coastal side, as exposed along the shores of Behm canal, a change in the invaded sedimentary rocks is noted from slates and argillites to phyllites and mica-schists and, still nearer, often to gneiss. The many types of contact hornfels are rare and spotted schists do not form an integral part of the complex. The strata are intensely folded and were undoubtedly deeply buried at the time of the granite invasion. In that position, deep seated metamorphic forces were active and had undoubtedly heated and altered the rocks to such an extent that the granite intrusion did not disturb their equilibrium greatly; its chief effect was rather to accentuate the process of crystallization already in force and to increase their power than to replace them by others. This coastal strip, whose contact with the granite can at present be traced only with difficulty, offers, therefore, an excellent example of the metamorphic changes produced by granite at a deep seated level.

It is significant that in the Ketchikan district no ore bodies of consequence have been found in this zone of deep seated metamorphism, while rocks farther away from the granite and at the same time nearer the surface during its invasion, frequently show traces of contact metamorphism (spotted schists and the like) and contain valuable metalliferous deposits. The folded character and lack of uniform structure of the strata near the granite contact may also account, in part, for the absence of commercial ore deposits, since they offer no decided lines along which concentration could take place as in the isoclinal schists of the Juneau district.

East of the inland border of the granite the character of the invaded rocks is noticeably different. The slates and sandstones are less altered and typical schists and gneisses are rare. Folding, and particularly faulting, are common and characteristic of the entire complex. The granite contact line is sharp and frequently traverses the bedding planes of the invaded strata. Although its general trend is parallel to the Coast Range the actual line in the Unuk river exposures undulates locally and crosscuts the strata at variable angles. The intruded rocks are often indurated and heavily mineralized with sulphides near the contact and show their evidence of metamorphism by the intrusive mass.

On comparing the metamorphic effects of the intrusive granite along its western and eastern flanks decided differences are thus apparent. On the coastal side, near the contact, the metamorphism is of the deep seated type, gneisses and schists predominate and are cut by innumerable pegmatite dikes ramifying from the granite. Mineralization by sulphides is not pronounced. Farther to the west, and at some distance from the contact, evidences of contact metamorphism increase, as also the degree of mineralization; valuable ore bodies have been discovered within this latter zone. Along the eastern border of the granite, on the other hand, the metamorphism is of the contact type, argillites and slates predominate and are often indurated and heavily impregnated with sulphides. Well defined ore bodies have been found in the near vicinity of the granite contact. The geologic interpretation of these data indicates clearly that the rocks to the east of the granite were less deeply buried at the time of its invasion than those on the coastal side. In other words, the inland rocks were then above the zone of deep seated metamorphism (rock flowage) and were, therefore, profoundly affected by the invading intrusives and accompanying pneumatolytic solutions. Furthermore, the mineral-bearing solutions emanating from the granite encountered new conditions of temperature and pressure on invading the adjacent sedimentary rocks and deposited then, as supersaturated solutions in their new environment, a portion of their dissolved contents, especially the metallic sulphides.

Although in such a large belt the phenomena of contact metamorphism are not so pronounced and concentrated as in the contact aureole of a small intrusive boss, they are more extensive and, on a large scale, equally as varied. It has been frequently observed that in a small contact aureole different contact minerals are found at different distances from the intrusive mass and that under similar conditions an evident relation exists between a given contact mineral and its distance from the invading rocks; and in a general way this law has been found to hold true for this eastern contact zone of mineralized sedimentary rocks.

The age of sedimentary complex east of the granite has not yet been determined accurately because of insufficient fossil evidence. It is probable, however, from the work of Dawson on Stikine and Skeena rivers that they were deposited chiefly during the Palæozoic Era.

Occasional belts of included sedimentary rocks were observed within the granite belt and found to be in a highly metamorphosed condition. They vary from argillites to mica, hornblende and calc schists of various types, and occur in long bands, often intensely folded, and trending usually parallel to the course of the range. As a general rule they appear more frequently near the mountain tops than in the valley. During the past summer two prospectors located a claim, the Cheechacho, about a mile below the International Boundary line on a vein two feet wide in such an included schist band, striking east and west and dipping 50° north. The vein carries pyrite, chalcopyrite, and pyrrhotite and is reported to give low assay values in gold. The schist band is cut by numerous offshoots from the intrusive batholite and deserves mention, since it contains the only vein on which work has been accomplished within the Alaskan portion of the Unuk river section.

Of interest are comparatively recent lava flows which were extruded near the granite contact, and, following Cañon creek and Blue river valleys to Unuk river, spread over its valley floor and forced its waters over to the south wall, where they now pass by way of the three narrow cañons indicated on the map. The volcanic ash from these eruptions can still be seen as black patches on the glaciers of the mountain peaks 8 to 10 miles distant. A few miles from the mouth of Blue river, the lava has dammed the valley to such an extent that a long lake has been formed and serves as a natural settling tank into which the turbid glacial stream flows, and from which it issues practically free from sediment.

The foregoing considerations tend to show that the belt of sedimentary rocks east of the Coast Range granite is a favourable one for prospecting, and deserves thorough investigation. As the inland border of granite lies entirely on the Canadian side of the International Boundary line, the Coast Range mineral belt is in British Columbia, and locations must be made in accordance with its laws.

MINERAL DEPOSITS.

The occurrence of placer gold near the headwaters of Unuk river and its tributaries has been known for many years. In the earlier eighties prospectors discovered gold-bearing gravels up Sulphide creek (See map) and spent several seasons profitably in extracting the gold by means of rockers and other primitive methods. The difficulties of transportation, however, were so great that they ultimately abandoned their claims. In the succeeding years occasional prospectors visited the region, relocated the placer deposits, and also discovered well mineralized veins carrying good values in silver, gold, and lead. A primitive trail was built along the north bank of the river, and access to the region thus facilitated. The present wagon road follows approximately the blazes of this old trail.

The most promising claims which have been staked are situated on Sulphide creek, and have been acquired by the company interested in construction of the wagon road. Other locations have been made near the head of South Fork, also near Boulder creek and Cañon creek (See sketch map).

SULPHIDE CREEK.

Recent discoveries have been made on this creek near its mouth, and consist of two veins which have been developed by several short drifts and open cuts. One of the veins outcrops along a narrow gulch and has been traced about one thousand feet up the gulch. It strikes usually N. 25° W., dips 30°-60° N.E. and varies in width from 2 to 8 inches. The vein minerals are chiefly tetrahedrite (gray copper), pyrite, sphalerite, galena and native silver ; near the surface they are usually altered and enveloped in a soft ferruginous matrix of weathering products. The native silver is a product of the surficial alteration of gray copper. About 100 tons of ore are reported to have been taken from this vein and to have given high assay returns, particularly in silver. The country rock consists of altered limestone and breccia with some quartzite and slate, cut by intrusives of several types. The second vein outcrops a short distance south of the first vein, and is exposed along the face of a steep cliff where it is easily recognized by its brown oxidized coating. At the surface it appears to be 20 to 30 feet wide and is heavily mineralized in spots with pyrite, fine galena (steel galena) and occasional sphalerite and chalcopyrite. Native gold is said to have been observed in the oxidized portions of this vein which has been prospected by a short tunnel 25 feet long at 1,400 feet elevation above sea-level. The vein shows distinct banding and strikes N. 5° W. with dip 80° to 85° E. A fine-grained basic dike is exposed along the west side of the tunnel. On both these veins the development work which has been accomplished is not sufficient to permit definite statements in regard to their future. The indications, however, appear sufficiently favourable to warrant the test which the company plans to give the property in the near future.

At the junction of Sulphide creek and Unuk river the river gravels contain some free gold, and fine colours can be seen in every pan of material tested. The gold is flaky and considerably worn. No thorough sampling has yet been done and depth to bed-rock is unknown. As the river valley, however, is wide and has passed through a long period of glacial erosion, it is probable that bed-rock is at some distance from the surface. Local irregularities were observed in the bed-rock floor near the placer gravels and similar variations may also be expected at the claims. It appears that these placers might be exploited by dredging, but large boulders are likely to be encountered.

South Fork.—Near the head waters of South Fork, below Sulphide creek, a second group of claims has been located 16 miles above its junction with the Unuk river, on veins within the sedimentary belt east of the Coast Range granite. These claims were not visited by the writer. Well defined deposits are reported and plans for future development are contemplated.

Boulder Creek.—Below South Fork on the same side of Unuk river prospects have been located on similar veins near Boulder creek, a glacial stream, about ten miles in length and rising near the Coast Range contact.

North Fork.—The territory drained by North Fork and by Glacier creek, two glacier-fed streams reported to be about 15 to 18 miles long respectively, has not been prospected systematically. The ore bodies which have been discovered are similar to others in this belt, and are frequently rich in galena, with good values in silver. The same statement applies to the region near the headwaters of Unuk river.

Cañon Creek.—In the vicinity of Cañon creek several ore bodies have been discovered, and are significant because of their close proximity to the granite contact along which Cañon creek has cut its course. The principal prospects near Cañon creek are the Black Bear claim and the Daily Boy group. The first is located on a vein 2 feet wide, outcropping along the selvage of a diorite porphyrite dike, and contains auriferous pyrite and pyrrhotite. The Daily Boy group is located in a gulch adjacent to Cañon creek, on veins occurring in altered black slates, argillites and quartzites. The entire assemblage of strata is folded and faulted considerably, and is characterized by intense induration and mineralization by sulphides, especially pyrite. On weathering they often become covered with a deep brown crust of ferruginous compounds, not unlike brown paint in appearance. The complex is cut by lamprophyric dikes of variable width and loose contact selvages. The veins which have been discovered in this gulch contain, besides pyrite, pyrrhotite and occasionally galena and sphalerite. No development work of note has been done on either of these prospects.

SUMMARY.

The geologic cross-section exposed by the Unuk river valley, across part of the Coast Range, consists of two parts: on the west, a wide belt of Mesozoic granitic masses, formed during the same general period and grouped into one great unit, the Coast Range batholite, which on the east intrudes partially metamorphosed, and probably Palæozoic sedimentary rocks in which ore deposits have been discovered. A discussion of the type of metamorphism of this rock-complex leads to the inference that its metamorphic changes were largely due to the contact action of the intrusive granite; that the impregnation of these rocks by metallic sulphides was essentially concomitant with their contact metamorphism; that at the time of the granitic invasion this sedimentary belt was nearer the surface than the invaded strata on the coastal side of the batholite; and that the different physical conditions resulting from differences in relative position to an intrusive are important factors in determining, not only the type and intensity of metamorphism, but also the kind and degree of sulphide mineralization.

From these considerations it is inferred that the sedimentary belt to the east of the Coast Range granite in the Unuk river section merits investigation and may reward careful prospecting for ore bodies. The difficulties of transportation which have been encountered heretofore will be materially decreased by the completion of the wagon road to Sulphide creek. Prospectors will then be able to devote a large part of their energy to the search for and development of metalliferous veins in the region.

Graham Island (of the Queen Charlotte Group, B.C.)

Dr. R. W. Ells.

The greater part of the season of 1905 was devoted to an examination of the coal deposits and other possible mineral resources of Graham island, the largest and most northerly of the Queen Charlotte group of British Columbia. The party left Ottawa on May 10th, and after a week spent in a further examination of the Quilchena and other coal areas in the Nicola Valley, which had been examined in detail the previous year, reached Vancouver on May 21st. Here, after hiring men and securing outfit and supplies, we sailed by the *Princess Beatrice* on the 26th, and reached Skidegate, via Port Simpson, on the evening of May 31st.

It was here found necessary to pack our supplies and outfit inland to the coal locations, and for this purpose a number of Indian packers were secured for several days. The first three weeks were spent in examining the coal outcrops at Camps Robertson and Wilson. The former of these is situated about eight miles northwest of Skidegate harbour, the trail taking off inland at the mouth of the Honna river, which is about four miles west of Skidegate post office (oil works), the Indian village being rather more than two miles farther east. Camp Wilson is situated about eight miles north of Camp Robertson. The trails were bad in places, the country being very rough and hilly. Several large seams were found; the shafts and tunnels, made some years ago, were pumped out, and the area was carefully studied in order to arrive, if possible, at some definite conclusion as regards the actual structure of the district. The details of this work will be published in the regular report on the resources of the island, now being prepared.

It was found impossible to force a way across the centre of the island from these camps to the head of the Masset inlet and we were, therefore, after finishing our investigations on these coal seams, obliged to return to Skidegate. Here, after some delay, a fishing boat was secured, and though no one could be found who knew the western coast, and though the chart of this part of the island was practically worthless as regards details, we started from the village by way of Skidegate channel westward. This channel affords a passage for boats at high water only, and after reaching the western entrance we examined the west and north coasts as far as Masset on the north end of the island, studying on the way the so-called oil-bearing rocks south of Frederick island, and the lignite deposits of Virago sound and Masset inlet, and the coast about five miles east of the entrance.

The shores of the large lake-like expansions near the centre of the island, were examined, and here our party divided, my assistant and one man with a light canoe ascending the Yakoun river to the lake at the head (Yakoun lake), a very difficult trip owing to the low condition of the water and also to the fact that, for much of the distance, the river was obstructed by heavy log-jams. It was found impracticable to take the canoe all the way to the lake, and the party, therefore, forced its way through the jungle along the stream until it struck a trail leading across to Camp Robertson, whence they made their way out to Skidegate.

After coming back with the boat to Masset village the examination of the north and east coasts was continued, but owing to a very heavy and prolonged gale we were detained for ten days at Tow hill, through the impossibility of rounding the dangerous northeast corner of the island known as Rose point. The black gold bearing sands of the east coast were examined, and they were found to extend south from Cape Fife nearly to Lawn hill, or to within about fourteen miles of Skidegate. This place was reached on Aug. 2nd and the boat for Vancouver was taken on the 8th, that city being reached on the 13th. As there is only one boat a month to the island this was the only possible course to pursue, the stormy season setting in before we left the island.

On reaching Vancouver the party was paid off, and a couple of weeks were spent on Vancouver island in company with Dr. H. S. Poole in order to compare the coal-measure rocks of the Nanaimo district with those of Graham island, my assistant for the season, Mr. S. C. Ells, B.A., making a trip in the meantime by way of the Nicola country to the coal fields of the Tulameen and Similkameen districts for the purpose of ascertaining their extent and value. It was found that to complete this investigation would require a whole season, and he thereupon proceeded round by way of Princeton and Penticton to the Okanagan lake where, also, coal deposits were reported. These were found to be practically of no economic importance. After an examination of this area, the party returned to Ottawa which was reached on Sept. 8th.

Leaving Ottawa on the 17th a trip was made to New Brunswick and to Nova Scotia, in order to study, with Mr. Hugh Fletcher, certain difficult points of structure connected with the Devonian, Silurian and supposed Cambrian of those provinces. On the return trip, by the request of the Department, an examination was made of the rock formations around the town of Sweetsburg, Quebec, to determine, if possible, the feasibility of finding by boring a supply of water for that town. The return to Ottawa was made on Oct. 9th. The compilation of the map of Graham island has been nearly completed, and the general report on the season's investigation is now being written.

The Nanaimo-Comox Coal-field.

Dr. H. S. Poole.

In accordance with instructions I left Ottawa on May 10th, in company with Dr. R. W. Ells for British Columbia, and together with him visited, via Kamloops, the region about Nicola lake where coal seams have been discovered and have been of late under exploration. Dr. Ells has already reported on the structure of the Quilchena field and on what, in 1904, he was able to see of the coal beds. Since that time the work of exploration has been confined to boring with a diamond drill, and I found the condition of the old openings after the dilapidations of winter did not enable me to judge, as a mining man, of the prospective value of the deposits which are evidently widespread, but only to note outcrops of coal imperfectly exposed in a weathered condition at several places on the slopes of Quilchena creek.

Near Coutlee on the Coldwater river access was had to the coal seams opened under a rock roof where the dip of the strata is at a moderate angle convenient for working. Further prospecting there seemed necessary along the outcrop and in depth, to determine the folding of the strata.

Excavations near Enderby at the head of Okanagan lake, whence samples of coal of promising appearance had been taken were not open to examination.

On reaching Victoria the courteous officials of the local government freely placed at my disposal such information as they possessed respecting the coal fields of Vancouver island, which it was your desire I should investigate, and endeavour to obtain a history of past workings for coal, with a view to elucidate the geology and further help to form an opinion of the future prospects of coal mining in that field. Through the kindness of Mr. W. F. Robertson, the Provincial Mineralogist, I made acquaintance with many who had been, and some who were now, connected with the coal industry of the island. Mr. E. B. Mackay, the chief draughtsman, kindly supplied me with copies of all available maps of his department. These, however, seldom showed, even approximately, the country roads, so the services of Mr. Thomas Budge were called in. With a cyclometer on his bicycle, and a prismatic compass he traversed the roads and ways in the neighbourhood of the mines and the district between Ladysmith and the entrance to Nanoose bay. I was exceptionally fortunate in securing the assistance of Mr. Budge who has large local knowledge of the country and its geology, and is further a coal mine manager by profession. Mr. Budge has also placed at the service of the Survey a collection of sections he has himself prepared from specimens of the rocks of the Vancouver series in the neighbourhood.

Mr. A. Dick, who has spent the best part of his life among the mines of this country aided me by the exercise of his retentive memory, and was as painstaking to keep me historically correct as he is zealous to require compliance with the law in his office of Inspector of Mines.

Records of several boreholes in both the Nanaimo and Comox fields were obtained through the kindness of Mr. T. Stockett, General Manager of the Western Fuel Co., and Mr. F. D. Little, General Manager of the Wellington Colliery Co., who also were good enough to furnish copies of maps.

Information was sought for data obtained in the course of prospecting and working the coal fields since they were reported on by Mr. J. Richardson in 1876-7.

Inquiry indicated that in the northern section of the island nothing further had been disclosed of the structure about Fort Rupert, Coal harbour, McNeil's harbour, &c., than what was described by Dr. G. M. Dawson in his Report of Northern Vancouver, Part B. 1886.

Mr. W. Hogan who was a good deal with Mr. Richardson in the seventies advises that prospecting on the coal measures at Gillies bay, Texada island, disclosed that the outcrop of coal seen there was only a patch, apparently on a fault.

Opposite Crofton on Osborne bay explorations were made on Salt Spring island, between the public wharf and Vesuvius bay. Two boreholes were put down in 1901 where some coal and black shale cropped vertically on the shore, one near the public wharf to a depth of 400 feet computed by the drill man 1,500 ft. over the coal. This is in line with the theoretical continuation southward of the horizon of the coal beds at Nanaimo, but the borehole record was not obtained, and general report makes the prospect unsuccessful and the ground faulted. At Koksilah in the Cowichan section an exposure of black shale reported to be coaly induced the sinking of a trial pit by Mr. Wood. The locality was not visited nor the statement confirmed that limestones in the neighbourhood, which is south of Duncans, are full of fossils.

Explorations outside the field of immediate examination, on a more extensive scale were those at Tumbo Island in 1893, when people of Victoria sank a shaft at No. 1 borehole, some 60 feet on the eastern side opposite its mid-length. Next they bored on the western side close to the water from a base blasted out of the rock, so I am informed by Mr. A. Dick. The bore reached a depth of 300 feet, having passed through bituminous shale and coal at 280 feet, the coal being so friable that a large quantity was pumped up in the bore. The channel alongside is reported to be 40 feet deep, and it was thought it gave access to the borehole. Contrary to his advice, says Mr. Dick, a shaft was sunk on the site of the borehole and this at 200 feet met so heavy a flow of water that it was abandoned, and then the 60-foot shaft was put down and stopped for want of funds. The surface on the island here slopes with the strata at 16° to the eastward.

It is of interest to prospective miners of coal in this locality to know that the grant of railway lands with their mineral rights, by the Act of 1887, does not include in the reservation the islands of the east coast of Vancouver island, and their mineral rights therefore go to the owner of the surface, with whom negotiations may be made. In the conduct of this inquiry, so far, attention was solely given to the sedimentary beds of the western littoral and no study was made of the basal rocks, the Vancouver series, of the interior, on which the coal bearing beds rest. These rocks and their metallic contents have been the special object of Mr. H. J. Sutton in the interest of Messrs. Dunsmuir & Son, the holders of the E. and N. Railway concessions, and he has travelled more among them throughout Vancouver island than any other trained observer. His collection of specimens of these rocks is unsurpassed, and he has noted, on a map of the island he has prepared on a large scale, the data he has accumulated.

The interest of Messrs. Dunsmuir & Son in much of the regions he has explored has now passed, with the sale of the railway, to the ownership of the Canadian Pacific Railway.

Besides the help obtained from government and colliery officials, information was had of private individuals, so much at least as they felt at liberty to make known; but I found myself unexpectedly barred from some records of exploration by the view that the secrecy insisted on while borings were in progress was still binding, although necessity for reticence and private interests had long ceased. In the East the practice I believe to be this, where coal is the object of search: to regard secrecy as no longer necessary when once the information obtained is utilized, and then place at the disposal of the public all secondary details, regardless of their cost. The result is that many structural details, of no financial value whatever to the explorer, but pertinent to this inquiry and only to be had by boring, have not been secured.

In the absence of official data, and with press notices of the closing down of collieries, an impression of late was produced away from Vancouver island that the workable coals are of less extent than Ottawa and the East had been led to suppose. Now there are some people who have a vague idea that a coal mine is like a spring of water, with a flow to last at least their day, and they do not realize what 'worked out' really means. What has happened is this: Wellington, which for many years was a busy centre of trade, has ceased to have an output of coal, the openings there have been abandoned, and in their stead mines at Extension have been developed, and Ladysmith has increased its population. At the same time it is true the coal operator in Vancouver island has had many disappointments, many unexpected difficulties to meet that are specialties of this coal field, in comparison, say, with the structure of the coal-bearing deposits of the opposite side of the continent.

In Cape Breton the beds carry a fairly uniform thickness for miles. Coal, sandstone, shale and fire-clay, each occur and re-occur in their due order of deposit, while in Vancouver the records of sections taken only 1,000 feet apart read so differently that it is hard to determine which are the beds continuous in both, which have been suppressed, and which have been unduly developed within that short distance.

Many of the difficulties that meet the miner are totally apart from questions of geological consideration. There are questions of supply and demand, questions connected with labour and questions of cost, all outside an inquiry touching the possible extent of the fields and the workable character of the coals. Active operations are at present in the hands of two corporations alone—the Wellington Colliery Co. and the Western Fuel Co. The business of the latter company at Nanaimo was suspended for some months by a strike of the miners, and the pits were closed during the time of my visit. I had, however, through the kindness of the colliery officials, opportunity to go below at both Extension and Cumberland.

Under guidance of Mr. John Matthews, manager at Cumberland, in the Comox coal field, the reported occurrence of anthracite coal was examined, together with exposures of coal altered and coked by igneous dikes on Browns river, some four miles from No. 7 slopes, which are being opened by the side of the Puntledge or Courtney river, two miles below Comox lake. At an exposure on a small water course half way between the two places a lava flow has converted some coal into a dense silvery coke. The exposure was limited, but so far as it permitted inspection the alteration extended but a short distance from the dike. From this point to Browns river the flow of andesite has made a hill 1,000 feet above the sea and capping the coal measures. What its effect may be on the underlying coal seams can only be conjectured; but neither here nor at No. 7 slopes could the coal mined be classed as in any degree anthracitic. The exposure at Browns river is above where Richardson took his No. 1 section, published in the Survey report for 1872–3, page 36; and it is opposite where the river takes its plunge in cascades through a narrow gorge of the older diabase against the outcropping sedimentaries. Mr. Matthews wrote an article on this locality in the 'Mining Record' of Victoria, November 1901.

Another unusual, close association of coal and igneous rocks occurs also in the same district, but in this case under reversed and ordinary conditions, the coal being the newer of the two. Right in the heart of the town of Cumberland, in the workings of No. 6 shaft, bosses of diabase project up through the pavement of the lowest seam at several places; there is no dislocation, the coal merely thins over them, but the contact is very close; in one case not an inch of what may have been mud intervenes between the weathered surface of the igneous protrusion and the coal. The bosses appear to have belonged to a spur from the hills; among its depressions first were deposited the grey shales and sandstones, these overlapping its sides apparently failed to complete the levelling up of the surface and so left these knobs of rock still exposed when the time came for the deposition of the coal seam. In a comparison of the conditions attending the workable seams of coal in the two great divisions of the coal field, the Nanaimo and Comox, this proximity of the workable coals to the unconformable rocks beneath in the latter division is in marked contrast with those in the former, where depths of 1,000 feet or even more of sediments, with thin coals and massive blue shales prevail.

Another important feature of differentiation between the two divisions is the association at Nanaimo of the working coals with thick beds of conglomerate, and their practically total absence in the worked portion of the Comox division.

As to the area of the coal-bearing series, it may, in general terms, be said to extend down the whole west coast of the island, but the area in which it is probable coal in workable thickness exists is very much less, while the area that may be regarded as proved is comparatively small. The difficulties in the way of exploration are numerous; vegetation is rank, the surface is largely disguised under thick layers of wash gravels, and there are no inducements to the public to prospect over the major portion of the more immediately promising ground, as these lands are held by the present coal operators who have no occasion to explore much ahead of their requirements. Still, if it be desired that a conjecture be hazarded of the quantity of coal exceeding a thickness of two feet, and within a vertical depth of 4,000 feet, an estimate of 600 million tons, though based on most incomplete data, would seem conservative and yet at the same time sufficiently large to allay apprehensions of any immediate shortage in the output.

The fossils collected in connexion with the above geological work have been submitted to Dr. Whiteaves, palæontologist to the Survey, for determination.

The Northern Extension of the Elk River Coal Basin.

Mr. D. B. Dowling.

The season's work was mostly of a preliminary character and much of the time was employed in topographic work.

The Elk river coal basin extends north and enters the valley occupied by the waters of the Kananaskis river. The area was entered from the north by the trail up the Kananaskis river. As the outfit had been left at Morley for the winter, supplies were obtained and the party were in the field in June, but as the mountains were then fairly well covered by snow, few ascents were made until the beginning of July.

A short base of 5,685·68 feet was measured on the shore of Kananaskis lake and a series of triangles measured extending southwest down the valley of the Elk river to a point twenty-eight miles distant from the station at the north end of Kananaskis lake. A check was then made on another base of two miles in length along a surveyed line forming part of a series of lines limiting the coal properties of the Elk River Coal and Oil Co. Four monuments or signals were built on the summit of the Elk range, which here forms the watershed, so that the triangulation might be carried eastward to embrace the coal basin within the mountains on the headwaters of Sheep creek and Highwood river. Photographs from which to plot the topography were taken at each station and several at other points which seemed desirable. As the transit used could only be read to single minutes it is very desirable that a primary triangulation of this area be undertaken by the government in order to better fix the positions of our stations. Our triangles, it is expected, will be extended east to meet the surveyed lines of the plains, but this entails the use of time which we can better devote to the geological problems before us. At the close of the season's work a few photographs were taken in the lower part of the Kananaskis valley to supplement the work of the previous season on the southern extension of the Cascade coal basin which was interrupted in September, 1904, by a period of smoky weather.

A general sketch of the structure of the region was obtained and may briefly be given. The southern extension of the Cascade coal basin does not reach very far south of the crossing of the Kananaskis valley. The impression which was formed from seeing the section on the stream the previous year was that the Cretaceous rocks formed a monoclinal block which gradually ran out to the south, but further evidence shows that this block was deformed by the west to east pressure, and, instead of having the western edge of the beds drawn up by the faulting, an anticline which broadens out to the south is found in the centre, so that the section on a small stream a few miles farther south reveals a double syncline and the beds become very much shattered. The base of the formation rises to the south and in a short time disappears, continuing possibly in two narrow folds the continuation of the synclines.

As the intervening mountains are not thoroughly explored it is not sure whether these folds can be traced as continuations of the beds crossing Elbow river and the northern end of the Sheep Creek coal area.

The Kananaskis valley in the upper part is a continuation of the same structural valley as that in which the Elk runs. To gain the eastern edge of the mountains, however, the valley is eroded through several limestone ranges crossing the first obliquely, but in the lower part more nearly at right angles. The southern end of the Cascade basin is thus cut by the river at about 45 degrees.

The upper valley is eroded along the edges of Cretaceous rocks, but very few exposures occur until the height of land is reached, and more are found in the valley of the Elk showing coal seams at several places. The mountains forming the eastern wall of this valley are practically continuous exposures of the same series of beds—the upper part of the Carboniferous limestones which dip west toward the valley. They form an unbroken wall from opposite the Kananaskis lakes southward for about fourteen miles where they become broken up into isolated peaks. Side valleys run into the range from the west but not far enough to form passes through to the waters of the Highwood. On the west side of the Elk and Kananaskis valleys there is a decided fault by which the limestones below are again brought up, but instead of forming a continuous wall as is on the east side considerable lateral movement has taken place since the break occurred. These beds have several strong folds which run oblique to the line of fault, and one of them running northwest towards the Spray river with apparently a fault along the eastern edge forms a strong valley. In this there seems a possibility of a narrow Cretaceous trough extending in that direction.

In the vicinity of the Kananaskis lakes the mountains west of this fault have been eroded back from the fault line and both lakes lie to the west of it. The stream leaving the lower lakes runs north along the strike of the rocks and then turns east. Where it joins the valley common to this stream and the Elk, it falls about 30 feet in a cascade over the quartzites, which appear again on the flank of the mountains on the east side of the valley. Sandstones of the coal measures are exposed a few miles below the falls but not along the stream. It is not expected, however, that coal in any amount will be found on the Kananaskis below the falls, and but few seams in the valley until near the height of land.

On the Elk, however, there is a wider portion in which the coal bearing beds are exposed and many seams have been opened up by prospectors for the Elk River Coal and Oil Co. The only seam that we found on the Alberta slope is in the middle of the valley just north of the height of land. There seemed to be about eleven feet of coal very much broken up on the outcrop exposure, but possibly of fair quality beneath. The Elk rises in two lakes in the mountains on the western side of the valley, similar in origin to those at the head of the Kananaskis river. These are fed from a number of glaciers on the slopes of the higher range behind and the stream which leaves the lake is often very milky during the warmer months. The valley has been well forested but large areas have been burnt over and the trails badly blocked by fallen trees. It seems to be in precisely the same condition as described by Dr. Dawson in 1884, the dead trees apparently standing for a long time before the roots rot sufficiently to cause them to fall. In the unburnt portions the forest is vigorous and there is a large quantity of splendid fir.

PROGRESS IN DEVELOPMENT WORK AT MINES.

At Canmore new workings are commenced in the Sedlock seam. As the outcrop is near the river and about a mile below the mines, this means the opening of a new mine and a spur of railway is built to it. The output will be thus increased, as the facilities for handling coal at the present slope do not admit of much increase there. As some of the seams which produce a large percentage of fine coal have also sandy streaks in the softer parts experiments in the cleaning of this fine coal has led to the installation of a washing plant which will be in operation this season, and the output in consequence will be of an excellent grade. Another seam above those now worked, called No. 6, is being tested, and, if of good quality, will add materially to the resources of the property.

Bankhead Mine.—During the year most of the permanent working plant has been installed. A battery of boilers with wide grate surface, to burn small coal, supplies steam for air compressors, dynamos, steam engines, &c. A large coal breaker and screening house has been erected and the temporary screens at the entry on B. level are probably removed.

In the mine the work so far has been mostly in excavating gangways on three levels and a cross entry on the lower or A. level. A rough approximation of the amount of preliminary work is given below. On A. level the entry along seam No. 2 reaches to 1150 feet from a point below the temporary entry. A tunnel through gravel on this level in the opposite direction reaches the river bank at the head of the spur from the railway where the shops, coal breakers, &c., are located. The cross entry at 45° to the strike of the measures is over 900 feet long and cuts 640 feet of the measures which are above seam No. 2. In this distance three strong coal seams are cut. Workings on a crushed seam spoken of last year as No. 3, are abandoned and it is now called No. 2½. Nos. 3, 4 and 5 appear to be valuable seams. The workings on No. 3 extend about 500 feet and on No. 4 an equal amount. On No. 5 preliminary work only has been started. From No. 4 a manway up the slope 500 feet to the surface is used for ventilation. B. level, 186 feet vertically above A. level, was opened from the slope of the hill as the original entry. On this the workings extend to a greater distance than on the others.

On No. 1 seam the gangway is 1,900 feet, on No. 2 seam the gangway is 2,760 feet, on C. level which is 192 feet above B. level No. 2 seam is opened by a gangway 800 feet in length.

As the coal in seam No. 1 is split up by a great number of slaty partings the mining of clean coal is difficult and is discontinued, but a long slope is being constructed along it to connect the different levels. The mining on each slope will be independent of the others and the loaded cars will be lowered down the slope to the first level.

As the coal is very tender much small coal is produced. Some of it can be used under stationary boilers but as there will be a large percentage of dust briquetting, will probably be resorted to. In this connexion it seems that a market for the small coal should be looked for in the production of power by the gas producer. In plants using lignite the efficiency can be increased by the addition of anthracite, and even the small anthracite, where it can be got cheaply, produces a good water gas that gives a high power result.

The Foothills of the Rocky Mountains South of the Main Line of the Canadian Pacific Railway.

Mr. D. D. Cairnes.

Having, with my assistant Geo. S. Scott, made the necessary outfitting arrangements at Morley we commenced making, according to instructions, a geological section along the Bow river from Cochrane to the limestone mountains just west of Kananaskis station. After finishing this we started work on the district to the south, using the Canadian Irrigation Surveys 'Topographical map of a Portion of the Foothills Region' prepared by A. O. Wheeler, as a base for our topography, making such corrections as were found necessary. My instructions were to study the geology of the region covered by this map, to place the same upon it as accurately as possible and to pay special attention to any minerals of economic importance. In addition to fulfilling these instructions a considerable time was devoted to collecting fossils and quite an extensive collection of plant remains and invertebrates was made, but owing to lack of time and the scarcity of fossils in some horizons, this part of the work was conducted at a considerable disadvantage.

BOW RIVER SECTION.

This section was made partly for correlation purposes, partly to ascertain if the coal measures seen to the south did not outcrop also along the Bow river, and partly in view of the fact that conglomerate appears in several places along this part of the river, somewhat similar in appearance to that overlying the measures to the south, which are now known to extend from a few miles south of the Bow to south of the Oldman river.

The conglomerate beds seen on the Bow river below the Kananaskis falls, very prominently at the Morley agency, and on a bend in the river two miles below, are part of an intercalated sandstone series in a dark shale formation resembling the Pierre, but in which have been found quite a number of Benton fossils. Specimens of *Cardium* resembling C. *Speciosum* are very plentiful in this sandstone series and on this account Dr. Hector in 1858 called the whole shale series the 'Cardium Shales.' The sandstones are about 200 feet thick near the mountains on the Bow river and are somewhat above the centre of the shales which are here about 700 feet thick. Below these Cardium Shales is a sandstone formation carrying fresh water shells and corresponding to the flathead beds farther south. This is about 900 feet thick on the Bow and is likely the Dakota, so that the Kootanie coal measures seen to the south, just east of the main Rocky escarpment and capped by conglomerate, are at a considerable depth below the conglomerates seen along this portion of the Bow. The intercolated sandstones above mentioned become thicker towards the mountains and along the Bow are thicker than noticed elsewhere. They consist of three distinct beds, each varying from a few feet up to 60 feet, and separated by dark shales. One or more are capped by a conglomerate of varying degrees of fineness and colour, but quite different in appearance from that above the Kootanie formation.

At the mouth of Jumpingpound creek, Edmonton sandstones and shales have a slight easterly dip of 5° to 10°. East of this to the end of the section the formation has a lower dip, becoming almost flat south of Cochrane station, where the rocks are Upper Laramie or what Dr. G. M. Dawson called the Porcupine hills series.

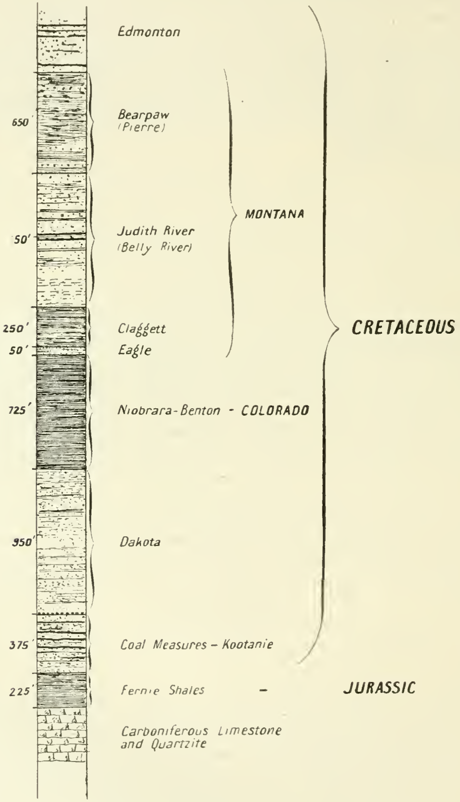
West of Jumpingpound to the mouth of Coal creek, the Edmonton rocks continue to dip east quite regularly, increasing the angle of dip to about 28° just east of the mouth of the creek. For about a mile west of here the rocks show considerable disturbance, exhibiting a series of folds accompanied to some extent by faulting. Thence to about two miles west of Morley bridge, a distance of approximately 15½ miles along the river the dips, as seen in the river banks, are, with only slight exceptions, all to the west; as the horizons are becoming lower this may, at first, appear strange, but the change is caused by reversed folding. Some faults were noticed west of Coal creek but they are only of minor importance and are thrusts with eastern downthrow of only a few feet.

The rocks at Coal creek, carrying the coal, are undoubtedly near the base of the Edmonton. From here west to Ghost river the rocks are all Edmonton, with the exception of a couple of exposures of Pierre-Foxhill; but for 2½ miles west of this the formations are very much folded and intermixed. Three exposures of Pierre outcrop and in between are interbanded Edmonton, Pierre and Foxhill rocks, consisting of light coloured sandstone beds frequently interbedded with dark Pierre shales. At a bend in the river 3½ miles west of the mouth of Ghost river, the first of the conglomerates, above referred to, appear. These, with the shales above and below them, occupy most of the valley bottom to within about a mile of the Palæozoic rocks, west of Kananaskis. Judith river sandstones are seen in a couple of places and overlie them next the mountains.

The sections as seen on the river, and in the hills to the north and south, vary greatly. This is particularly so from the mouth of Ghost river to Coal creek. In the river banks the strata all dip towards the west, while in the hills the dips vary from flat to east, forming part of a large anticline extending from the limestone west of Kananaskis to the mouth of Jumpingpound creek. The sandstones are not as liable to be folded as the softer, more pliable shales, and, consequently, the upper part of the anticline is regular, while the inner and lower part is folded and pushed over

South of Bow River.

By working south of the Bow river, and especially in the area around the Moose Mountains, our expectations of finding the Lower Cretaceous, and thus having a section in the foothills of Alberta from the Carboniferous to the Laramie, were realized; the Moose mountains forming an anticlinal ridge, or rather a qua qua versal of Palæozoic



Section of the Cretaceous, South of Forgetmenot Ridge on the North Branch of Sheep River, Alta strata, having Fernie shales overlain by Kootanie rocks lying on them and dipping away on all sides. Just west and south of this ridge is another, the Forgetmenot ridge, narrower and less prominent than the Moose Mountain ridge, and formerly mapped as being connected with it, but at their closest points they are separated by about 1½ miles of Cretaceous and Jurassic rocks. This latter ridge is not as regular as the more easterly one, being faulted nearly its entire length along the eastern side, and thus overlying the Cretaceous for this distance. But along its western edge, and at the north and south ends, the Kootanie formation and Fernie shales are exposed. Thus, these two ridges afford an excellent opportunity for studying the Cretaceous, a complete section being exposed, commencing with the Kootanie and passing up within a few miles into the Edmonton. The thickness of these Cretaceous beds was estimated in several places, an average section being obtained just to the south of Forgetmenot ridge, on the north branch of Sheep creek.

The Edmonton is chiefly a brackish-water formation, consisting of frequently alternating, light coloured, soft, sandstones, clays and shales, usually fairly well bedded. This formation, which forms the top of the Cretaceous, becomes harder towards the mountains and contains a number of workable seams of good lignite.

The Pierre-Foxhill is a marine formation, consisting chiefly of dark gray to brown, and even nearly black, shales of very uniform appearance. They contain numerous layers of ironstone bands and nodules, and a few beds of soft, light-coloured sandstone.

The Judith River or Belly River is a fresh water and brackish formation, consisting of light-coloured sandstones, clays and shales. It is very similar to the Edmonton, but is, towards the mountains, harder and somewhat finer grained; contains abundant remains of tree trunks, twigs, leaves, &c., but very few invertebrate remains. White, cross bedded, and somewhat massive, sandstone beds are quite characteristic of this formation. Ironstone nodules, often of large size, are of frequent occurrence.

Below the Judith River formation are the marine shales, called by Dr. Hector the *Cardium Shales.* The upper part of this formation consists of dark clay shales of very uniform appearance, and much resembling the Pierre. Below these come the sandstone series and conglomerates above mentioned. These are followed by more dark shales similar in appearance to the first and also resembling the Pierre, but are in all probability Niobrara-Benton. The three divisions of this shale series stratigraphically correspond, respectively, to the Claggett, Eagle and Niobrara-Benton formations.

Below these is a sandstone formation, somewhat brightly coloured near the top but becoming darker and very hard farther down. At the bottom, however, is a conglomerate bed from 10 feet to 40 feet thick, capped by a white fine grained quartzitic sandstone, generally about 20 feet thick. Dark blues and greens are prominent colours, especially near the top, and here there are also a few bright red bands about 2 feet wide. Fresh water shells are found near the top, and numerous plant remains were found throughout the formation. These rocks are much darker, finer grained and harder than those of the Judith River or Edmonton, and are probably Dakota.

Immediately underneath the Dakota conglomerate is usually a coarse dark sandstone bed from 10 feet to 30 feet thick. Below this are dark shales, sandstones and coal seams, followed by a very prominent brown sandstone bed 30 feet to 75 feet in thickness. These comprise the *Kootanie* of the foot hills, which is considered the base of the Cretaceous in this district. There are numerous reasons, however, which will be given in the detailed report, for considering the Kootanie to be Jurassic.

Next below the Kootanie are the *Fernie Shales.* The upper part of these consist of brown sandstone and shales, gradually changing into very fine-grained, closely bedded and almost black shales, which constitute the greater part of the formation. From fossils found it is now certain that these Fernie shales are Jurassic.

Only a few of the fossils collected this season have as yet been examined, so the results of their determination will be given in the final report.

GENERAL GEOLOGY.

Along the eastern side of the mountains the contact between the Palæozoic rocks and the Cretaceous is a faulted one, with eastern downthrow. East of this lies that portion of the foot hills described in this report. Enormous and long continued pressure from the southwest has caused the geology of this district to be, in places, very intricate, the rocks being all more or less folded, and the folds usually pushed over and often faulted. The high rugged limestone ridges, the Moose and Forgetmenot, somewhat to the west of the centre of this area, are the most marked results of this pressure here, and have added much to the complexity of the formations. The Cretaceous strata were upraised around them on all sides, and after long periods of erosion they now appear with upturned edges high up on the limestone hills; with the exception that along the eastern edge of Forgetmenot ridge the pressure has been too great and the fold has broken, causing the limestone to overlie the Cretaceous rocks in a similar manner to that of the contact east of the main Rocky Mountain escarpment.

For the final report, east and west sections are being prepared; these are intended to explain such irregularities. One is along the Bow river, where the formations are uninfluenced by the Moose mountains. One is approximately along the Elbow river through Forgetmenot and Moose ridges, and another is just south of Forgetmenot ridge. This last is probably the most complicated, showing as it does the close, reversed, and somewhat distorted folding of the Cretaceous rocks over the limestone, which takes the place of the long fault on the eastern side of the ridge where the limestone overlies the Cretaceous.

COAL.

In a few places thin layers of coal and carbonaceous matter occur near the base of the Pierre, but no coals of value were noticed on this formation in the district examined this season.

Lignites, which are, as a rule, of very good quality, were found in a number of places in the Edmonton and Judith River formations. Workable seams were seen at several places along the Bow river west of Cochrane and on the Morley reserve south of the river. There are also workable seams on Jumpingpound creek, N.W. ¼ sec. 19, tp. 25, r. 4; on Bragg creek, sec. 7, tp. 22, r. 5; on Fish creek: N.W. ¼sec. 7, tp. 22,

r. 3 ; N.E. ¼ sec. 4, tp. 22, r. 3 ; S.W. ¼ sec. 21, tp. 22, r. 3 ; south branch of Sheep river : S.W. ¼ sec. 29, tp. 19, r. 4 ; S.E. ¼ sec. 30, tp. 19, r. 4.

Those seams on the Morley reserve, on Jumpingpound creek, and on the south branch of Sheep river are the best, according to analyses, and surface indications.

The Kootanie coal measures extend all around the Moose Mountain ridge ; along the west side of Forgetmenot ridge ; from 'Gleason's Meadow' along the east side of the ridge through 'Gleason' and 'Lower Camp' ; along the northwestern and eastern slopes of 'Coxcomb' mountain, near its summit, and thence to the north end of Forgetmenot ridge ; on Jumpingpound creek, north of Coxcomb mountain ; on the south branch of Sheep river, north of 'Hoffman'; and in a few other places as shown on the map to accompany the report of this district.

The measures vary somewhat in thickness, amount of coal, and number of seams. Sections of the Kootanie were measured in a number of places outside the mountains and were found, in each case, to contain 3 or 4 workable seams and a total of from 22 feet to 30 feet of coal. One section measured just inside the mountain, near the head of the south branch of Sheep river, was found to contain over 40 feet of coal. There may, however, be more coal than was seen, as our work was chiefly to locate the measures, so that persons looking for coal will only have to prospect along them for places where the coal is best and most accessible. In my final report will be given details in regard to all coals seen, in the Edmonton, Judith River and Kootanie formations. Sections of measures, widths of seams, quality of coal, analyses of average samples, accessibility, &c., will be given, for which there is not space in this summary report.

Conclusion.—The Kootanie formation which was formerly supposed to exist only within the mountains, has been found in the foothills, carrying valuable coal measures. The formation and measures are much thinner here than within the mountains, showing the improbability of their extending eastward past the disturbed area of the foothills. They should, however, prove of considerable economic importance, particularly, as the measures are quite accessible up most of the rivers and streams of the area, which cut through them, flowing eastward from the Rockies.

The lignites, while not of as good a quality as the coals of the Kootanie, are still very good lignites and, as a rule nearer a market, often more accessible, and will become an important asset to the district.

The Surface Geology of Manitoba, Saskatchewan and Alberta.

Dr. R. Chalmers.

The winter of 1904-5 was spent in the office in routine work and in preparing a bulletin on the clays of Canada. In collecting the material for this bulletin it was found that the data from the west were meagre and incomplete. It was, therefore, considered advisable to postpone publication until more information was obtained from the new provinces. Meantime I was instructed to make such an examination of the surface geology ot these provinces, and of all matters relating thereto, as was possible.

I left for Winnipeg on the 16th of June. The first two or three weeks were spent in the vicinity of that city, and in examining the country southward to the International Boundary, northward to Winnipeg and Manitoba lakes, and eastward and westward to the province boundaries. The eastern part of Saskatchewan as far south as Estevan, also that part north of the main line of the Canadian Pacific railway were next traversed, after which I proceeded to Regina and from there examined the plains northward to Prince Albert, southward a considerable distance, and westward to Moose Jaw. Going west from Moose Jaw to Calgary the latter place was made my headquarters for some weeks, and the whole surrounding country south of the North Saskatchewan river and west to the Rocky Mountain divide was traversed. The work here proved to be of great interest. Numerous exposures of the surface beds were examined, especially along the river banks, and in gravel pits, brick yards, etc. Good sections were obtained in a number of places, showing the character and succession of the beds. The scenery of the Rocky mountains here has been so frequently described that it need not be referred to; but the tremendous erosion which these mountains have undergone seems to have been but little commented on. Yet an observer looking at the trenching and denudation which these mountains have suffered must acknowledge that it is to them that the thick beds of gravel, sand and clay now occupying the plains to the east are due.

These plains are in reality the northern extension of the Mississippi and Missouri valleys, and the surface beds underlying them appear to have been similarly formed on both sides of the International Boundary. Two boulder-clays were everywhere noted. These have a thick interglacial series of sands, silts, gravels and clay. The boulder-clays, so far as examined, do not occur in continuous sheets, but in lenticular, detached masses. The two were observed, one above the other, in the same sections in the Bow and Belly valleys, and in a number of other places to the east.

The transported boulders found on the plains seem to have been largely derived from the boulder-clay of the second glacial period by its denudation. Those belonging to the Archæan rocks are found scattered everywhere, nearly to the base of the Rocky mountains. Their presence on the higher levels has not yet been satisfactorily explained.

During the second week of September Medicine Hat was visited, and a day or two was spent in securing a section of the surface beds there, and in obtaining the facts relating to the gas wells. Information was kindly given me by the manager of the gas company. The town is lighted and heated by natural gas and owns the wells and plant. On leaving Medicine Hat I returned directly to Winnipeg. From this city Birds Hill, Deloraine, Turtle mountain and Napinka were visited. Turtle mountain, like the other mountains of the prairies, is chiefly morainic. Afterwards I went out to Dauphin, Gilbert plains, etc., and examined Riding and Duck mountains, Returning to Winnipeg a trip was then taken to Fort Frances where a large peat bog occurs, on which a new peat plant has just been set up. Brick works are also in operation here. Thence I went to Port Arthur, returning to Winnipeg on the 1st of October. After examining some places north and east of Winnipeg, not previously visited, I left for Ottawa, reaching there on the 7th of October.

Brick clays are common in Manitoba, Saskatchewan and Alberta, and large quantities of bricks are manufactured at or near the principal towns. Pressed bricks also are now coming into use, and in a few places these are being made. Tile is very little used, but the clays are quite suitable for its manufacture.

The Region South of Cape Tatnam, Hudson Bay.

Mr. W. Stewart Dobbs.

In the month of July I was instructed by Dr. Bell to make a geological reconnaissance of the region lying southward of Cape Tatnam to the eastward of York Factory on Hudson bay. From a point seventy or eighty miles due south of this cape the streams radiate in all directions, and the district around it was described and represented on the maps as being considerably more elevated than the extensive level country surrounding it. It was supposed that this physical condition might indicate an area of older rocks than the unaltered and nearly horizontal limestones of the low country, especially as such areas have been proved to exist at Sutton Mill lake, southwest of Cape Henrietta Maria,* and on the Winisk river.† The existence of a large area of such rocks would constitute an important feature in the geological map of the Dominion and it might be expected to possess economic value from containing metallic ores.

It was thought that the best way of reaching the district in question was to proceed to the Shamattawa river and ascend one or more of its branches flowing from this area.

My instructions also directed me, in going to this ground, to follow for a part of the distance a different route from any of those which had been already explored by Dr. Bell himself in 1878, '79 or 1900, or by his assistant, Mr. A. S. Cochrane, in 1879. I was to make track surveys and geological examinations of these routes, so as to add to our previous geological and topographical knowledge of the country. I was also to make copious notes on their physical features, their forests, fauna and flora, and of all other matters which might some day prove of interest.

In accordance with these instructions I proceeded, via Lake Winnipeg and Norway House, to Oxford House, where the final arrangements were made for the long canoe voyage ahead.

With Mr. Moir, of the Hudson's Bay Company, I left the route usually travelled and proceeded to Gods lake, by way of Back lake, Trout river and Knee lake, to the mouth of Wolf river (Meachan sipi), thence up Wolf river (with three portages) to Swampy portage lake, over the Swampy portage to Gods lake, and on to the Post on its shore. The Indians told me Swampy portage was comparatively dry, still one sank to the knees in the sphagnum moss at every step.

We reached Gods lake post Saturday the 12th and left Tuesday August 15 for the Manitou sipi, or Gods river, a journey of about twenty-three miles, including five rapids, the Red Fox, White Teeth and the three Ogema rapids.

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*See description by D. B. Dowling in the Summary Report of the Geol. Survey for 1901.
†See Wm. McInnes' description in the Summary Report for 1903.

The country passed through is very rocky, with thin coverings of soil. and is only sparsely wooded. The Manitou is a large, rapid river about 220 miles long following its course to its junction with the Shamattawa, near the Deer Lodge winter post of the Hudson's Bay Co. Progress down the river was comparatively easy on account of the assistance of the current. The waters of the Manitou river teem with sturgeon, trout and pike, while in the valley there are ducks and geese. Of the fur-bearing animals foxes are the most numerous. Below the junction of the Red Sucker, the Manitou becomes wider and swifter, with banks of white boulder clay or till about 80 feet high. Rock exposures were infrequent aud finally disappeared beneath an overburden of drift material.

During the entire journey from Gods lake to the Shamattawa, I saw only four camps of Indians, made up of about nine tepees and tents, covering sixty souls, men, women and children.

The clay banks kept rising until, at their highest, within the last sixty miles, they presented nearly ninety feet of white till that had been cut into by the river. The nomenclature of these rivers, according to the present Indians, does not correspond with that of the maps. The Shamattawa, according to the latter, includes part of the Shamattawa proper and sixty miles or so of the Manitou or Gods river and Red Sucker river. The Manitou river flows from Manitou or Gods lake into the Shamattawa. The Red Sucker runs into the Manitou about 60 miles southwest of this junction.

Hereabouts are 25 miles of rapids ending in the Mistassini powistik or Big Stone rapids, the water rushing over and foaming around gigantic boulders. After passing this rapid, the river becomes broad and deep, with here and there a few small rapids, until the Limestone rapids of the Shamattawa are reached. The country abounds with life, both feathered and furred. We saw abundance of coloured foxes, and mink was very common. Every marsh or weedy bend in the river sent up its quota of ducks on our opproach and several times later in the season we saw large flocks of wild geese moving southeastward. The river teemed with fish, principally young sturgeon, speckled trout and pike. One reach, nearly twenty miles long, near Puskajewan, is an ideal place for the breeding of wild duck.

We pushed up the Pekano river, struggling against shallow water and a strong current, in cold, rainy and foggy weather. The Pekano is a river from about 60 to 300 feet broad, with a current varying from four to seven miles in some places. No outcrop of rock was visible at any spot in the whole 130 miles of its length that I travelled, at which distance the river became so shallow that it was impossible to follow it farther.

The country from the Shamattawa river east was undulating and on an average of 75 feet above the river valley, which was about two miles across. The banks were all drift material, clay, boulders, stones, &c., and the country was monotonous in the extreme. Mile upon mile, as far as the eye could see, the country undulated to the horizon line. It was sparsely wooded with a stunted growth of coniferous trees, constituting a hopeless tangle of fallen and half-fallen trees, relics of the numerous forest fires that have taken place throughout this region, with ravines here and there where small streams cut their way to the river. Mosses and lichens cover the ground wherever there is a breathing space. A few stunted bushes, including the Labrador tea, were all that was necessary to complete a picture of desolation. At the end of the navigable part of the river, the ground became fairly flat with a slight downward slope to the northeastward.

After examining both sides of the river valley as thoroughly as time would allow, and searching the river bed for any possible clue that would lead to finding an outcrop of rock, I decided, in the absence of any rising ground, to abandon this part of my trip. No fossil-bearing erratics were found on the river over fifty miles from the Shamattawa, while fossils were very abundant in the pebbles and stones within that distance.

By this time—the end of August—the weather had turned bright and cold, and we had severe frosts every night; we returned to the junction of the Shamattawa and Manitou rivers with one canoe in a very leaky and frail condition. On the Shamattawa we were again overtaken by bad weather—rain, fog and wind from the northeast; the woodland cariboo were crossing the river in droves, and this enabled us to lay in a good supply of fresh meat, in addition to which we killed geese, duck, sturgeon, whitefish, &c.

It was too late in the season to look for outcrops south of the Pekano river. I, therefore, decided to retrace my steps to Norway House in order to catch the last steamer. The weather, which had been bright and cold for a couple of days, now began to get insufferably hot.

From Big Stone rapids on to Gods lake post we had strong head winds, and this, with the currents and rapids, made our progress difficult. We reached Gods lake post on September 12th, after a very rough passage from the mouth of the river, the waves running very high. At the post there was much talk about a cinnabar deposit, distant a day's journey, but in which direction nobody seemed to know.

Mr. Hyer, of Winnipeg, the trader in opposition to the Company, has a gold location on Island lake near Manitou lake, and samples of ore, stated to have come from there, were very rich. On the return journey, on the Echamamish, I came across an interesting occurrence of molybdenite at a contact between rocks of a gneissoid character with an intruded plutonic rock.

After waiting six days at Norway House we started for Warren's Landing, and arrived in Ottawa on October 16th.

Pursuant to instructions, I carefully noted the forest growths and burnt areas, and beg to submit the following notes:—The woods from Norway House and on up the Echamamish were very young, none of the trees appearing to be over fifteen years old; in some parts the fires have been quite recent, and, indeed, in several directions, we could see heavy clouds of smoke. The season had been very dry, and these fires must have created great destruction among the forests.

The forest in the neighbourhood of the Robinson portage was denser, and the trees seemed to be, on an average, from 15 to 30 years old. The same condition of things was noticed down to Oxford lake. All along the north shore of this lake fires could be seen, and about three miles northwest of the Hudson's Bay post a huge fire was raging and continued to burn, it is said, for nearly three weeks.

From Oxford lake on to Mossy portage the forest growth was very young, and gave abundant evidence of at least one recent burning. At Gods Lake post Mr. Swain showed me some fairly large timber that came from 'down the bay.' Some of the trees must have been forty-five years old. On entering the Manitou river three-fourths of the region from the lake to the Red Sucker river has been burnt once at least in the last ten years.

From the Red Sucker rapids to the Shamattawa rapids occurs some heavy forest growth; young trees from ten to fifteen years, and some fine groves of trees about twenty-five years old. In some districts that have not been burnt, the trees are so densely crowded that they are dying of some rot disease, the effects of too little sun and air. They are being literally smothered to death. The forest growth is largest and thickest along the courses of the streams and thins out away from the river banks.

The conditions are the same on the parts of the Shamattawa that I travelled, and the trees show a decided tendency to fringe the river banks. At the junction of the Shamattawa and the Pekano, on the east bank of the Shamattawa, is a remarkable grove of large trees. There were several stumps with a large number of rings—one with 53 rings, one with 63, and one with over 76. This grove was the best that was noticed in my travels.

The Pekano is fringed with willow bushes, interspersed with long grass, backed by two or three kinds of small coniferous trees, with a few small birches and two species of poplar, the trembling leaf and the rough bark. The country here has been burnt over at least once in the last ten years, and in some places there are evidences of previous conflagrations. The conifers, therefore, have not attained a growth of ten years, while the birches, poplars, &c., average about six years. Of course, there are a few isolated places where the forest growth has attained to a larger size; and I counted four groves, besides the one mentioned above, of about fifty trees, with ages varying from 23 to 42 years.

The country away from the river valley is a vast, slightly rolling plain with burnt sticks standing up like hop poles or lying in an indiscriminate tangle on the ground, with young forest growth springing up among them.

The frequent burnings are nearly always due to the carelessness of the Indians. Several times our party has put out fires that started from unextinguished camp fires.

There is no reason why most of this region could not, if protected from fires, produce larger trees which might be of great value to the country in the future. The institution of a Forestry Department would be of great benefit to the country, especially to the particular area now referred to, and the Indians could be made most useful forest rangers.

The Pekano is, practically, one pebbly rapid from source to mouth, and from what I could find out there is no rock outcrop anywhere in the country drained by this stream, or to the northward. I have already referred to the Limestone rapids at the junction of the Shamattawa and Manitou rivers. For about forty miles up the Pekano the pebbles were nearly all of limestones and I succeeded, with difficulty, in finding a couple of pieces showing characteristic fossils.

It is not until the Mistasini rapids are approached that any rock exposures are seen. At that point a pinkish acidic plutonic rock occurs, extending over twenty-five miles.

The rocks of the Manitou river can, for convenience sake, be divided into three classes :—an acidic igneous complex, which seems to be the basement of the rocks in this district ; a conglomerate with associated schistose rocks at Goshabisk rapids ; and, lastly, dark basic rocks occurring in some places in considerable masses and in others as dikes. The last named rocks are certainly younger than the acidic igneous complex and they sometimes cut the sedimentaries.

The light-coloured gneissoid, acid rocks occupy by far the largest area and appear in several parts of the river valley, where they are intruded by the younger basic series. They are generally composed largely of quartz, with orthoclase, some albite, mica, hornblende and magnetite. The rock is granular in texture, and shows in parts distinct curved jointing. In some cases it shows very little quartz, and practically may be classed as syenite gneiss.

The only sedimentaries observed were the metamorphosed conglomerate, showing great distortion of the included pebbles, which appeared to be composed chiefly of rocks of the granite family, derived from the underlying gneissoid rocks, with a few quartz pebbles. The matrix of the conglomerate is distinctly schistose in character, resembling a chloritic schist. These sedimentaries dip at an angle of 18° and strike N. 70° E. In these schists near Goshabisk rapids are small veins of calcite with hornblende, carrying pyrrhotite, pyrite and chalcopyrite.

Farther to the southeast is a large outcrop of dark greenish-gray igneous rocks, which are again succeeded by gneissoid rocks. The basic igneous rocks are composed for the most part of feldspar with large proportions of hornblende and pyroxene. In places, isolated outcrops of this rock are decidedly schistose, with distinct jointing in two directions. These rocks, as at Bell rapids, are seamed in all directions with veins of quartz varying from a fraction of an inch to six inches in cross section.

Owing to the heavy burden of glacial drift material, the rocks in this district cannot be studied over any great area. My limited time and the difficulties of transport prevented me from examining them in detail.

A Survey of the Coast of Hudson Bay from York Factory to Severn River.

Mr. Owen O'Sullivan.

In accordance with instructions authorizing me to survey and explore the southern coast of Hudson bay, I proceeded on May 5 last to Winnipeg, where I procured my outfit and laid in all the necessary supplies for the expedition. Mr. Jos. de Lorimier acted as my assistant. We left Winnipeg on May 27, arrived at Warrens landing on June 1st and reached Norway House (the Keewatin headquarters of the Hudson's Bay Co.) the following day. Mr. Donald McTavish, the officer in charge, received us very kindly and supplied us with four of his best Indian guides for our trip to York Factory.

We left Norway House on June 5 taking the canoe route *viâ* the Hayes river which was surveyed by Dr. Robert Bell in 1877. This canoe route is the well known highway between Hudson bay and Lake Winnipeg and has been travelled by Indians, early pioneers and officers of the Hudson's Bay Co., for centuries.

Owing to an exceptionally light snowfall during the winter and very little rain in the spring, it was only with great difficulty that we got our loaded canoes down the shallow rapids.

Ice and snow were occasionally seen in the ravines and where drifts had accumulated during the winter.

We arrived at York Factory on the 18th of June. This Hudson's Bay Co.'s post is situated on the north bank of the Hayes river about five miles from its mouth.

For a week after our arrival, the ice from the bay was carried by the tides up and down past the post, preventing us from starting eastward on our work; during this delay several astronomical observations were taken and occasional runs were made inland.

Mr. Boucher the officer in charge of York Factory, advised me to start with three canoes and try and reach the right bank of Ship river, a distance of about thirty-two miles, and thus avoid the marshes that extend that far and then send back two canoes and walk the coast to Fort Severn, assuring me that the walking was good over sandy ridges.

Accordingly on June 26, a strong south wind having driven the ice out to sea, we started a micrometer survey from the mouth of the Hayes river eastward and on reaching the east bank of Ship river, sent back two canoes, keeping the largest one to forward supplies and outfit and ferry us across the mouths of the different streams, while with four men I continued the micrometer traverse walking along shore to Fort Severn, a total distance of 240 miles.

The salt marsh which lies between York Factory and Ship river extends inland from one to three miles beyond high water mark and almost reaches the tree line. From Ship river to Fort Severn there are also several salt marshes lying between high water mark and tree line, but none of them are of any great extent. At low tide the water recedes from half a mile to four miles, leaving only mud flats strewn with boulders.

Four good sized rivers enter the Bay between York and Severn,

1st	the	Broad river 78	miles	from York.
2nd	"	Kaskattamagan 95	"	"
3rd	"	Kettle river 126	"	"
4th	"	Goose river 196	"	"

The largest is the Kaskattamagan, which enters the Bay by three channels, forming two large islands at its mouth. We waded all these streams except the Kaskattamagan and never had water above our waists at low tide.

From Ship river, old wave-made beaches or sand ridges lie parallel to the watei line most of the way eastward to Fort Severn, generally three in succession, but in some places there are as many as six between high water mark and tree line. Occasionally they are mixed with shells, driftwood and other debris and are from one to four chains in width and from half a mile to five miles in length. Near the tree line some of these ridges attain an elevation of about 30 feet above the present high water mark. Numerous fresh water ponds or lakes lie between these ridges. The largest seen was about three miles in length and ten chains in width and about ten feet deep along the centre line.

In the second ridge ten chains back from the present high water mark and fifteen feet above it, we found the remains of a ship partly buried in the sand. There was nothing to indicate how many years have elapsed since the ship was wrecked on this coast, but it must have been within comparatively recent years. Near Cape Tatnam the skeleton of a whale was found on the inner or south side of a range of dunes at an elevation of about fifteen feet above high water mark of to-day. Dunes having an elevation of fifty feet above present high water mark are seen at 163 miles from York Factory. These facts show that the land is rising somewhat rapidly along this coast.

One of the greatest difficulties met with in surveying this coast, is the floating ice which seldom clears away before the middle of July and is sometimes held there by prevailing northerly winds until the beginning of August.

When these ice floes, which are sometimes 20 to 40 feet in diameter, are driven ashore at high tide by the north wind, they become stranded and prevented us from reaching the shore; our canoe would thus have to remain imbedded in the mud until the next high tide or else we would have to portage all our baggage, which was seldom practicable.

From the 1st to the 12th July we were thus ice bound near Cape Tatnam and during all this time the thermometer on an average read about 45° Fahr. in day-time and at night it would descend below freezing point and the weather was generally foggy, another source of delay in micrometer work.

The country between York Factory and Fort Severn for about fifty miles inland is very low and flat. I took several walks through it while being detained by ice and fog and found it to be mostly muskeg.

We arrived at Fort Severn on the 3rd of August having made a continuous micrometer survey all the way from York Factory. Mr. Purvis, the officer in charge of the Hudson's Bay Company's post at Winisk arrived there the same day with a coast boat going to York. This gentleman and Mr. Laing, the officer in charge of the Severn, advised me to take this opportunity of returning to York, as the season was too far advanced to attempt continuing the survey farther eastward without running the risk of having to winter at Winisk. We therefore returned to York by this boat, arriving there on the 16th of August.

From a geological point of view there is nothing very interesting to be seen along that part of the Hudson Bay coast which we traversed. Nothing but mud flats and boulders looking seaward, and marshes, dunes, ponds and muskeg, bordered by stunted evergreen woods, chiefly small spruce, looking landward.

Speckled trout and white fish are plentiful at the mouths of all the rivers entering the bay. When at the mouth of the Kaskattamagan, we set the net at low tide and at the following low tide had over a hundred trout and white fish, over two pounds each. Caribou and red deer are also plentiful. Ptarmigan and duck are also numerous there. Foxes and wolves were seen all along the coast.

We spent a couple of days at York repairing our canoes and procuring supplies for our homeward trip by the Hayes river and Lake Winnipeg, and left on the 19th of August and arrived in Ottawa on the 18th of September.

My thanks are due to Mr. C. C. Chipman, Head Commissioner of the Hudson's Bay Co. and to the following gentlemen :—Mr. D. C. McTavish, Chief Factor of the Keewatin District, Mr. C. Sinclair of Norway House, Mr. Boucher of York Factory, and Messrs. Laing and Purvis of Fort Severn for the many kind services rendered me in carrying out the expedition.

The Headwaters of the Winisk and Attawapiskat Rivers.

Mr. William McInnes.

My instructions for the past summer's work called for an exploration in that part of the district of Keewatin, lying about the headwaters of the Attawapiskat and Winisk rivers, and between the Winisk and Trout lake, near the head of the Fawn branch of the Severn river. The route from Dinornic by the way of Lac Seal, Lake St. Joseph and the Albany river was chosen as affording the easiest way of taking in the necessary supplies.

This route had previously been travelled by several explorers and its geology was fairly well known. Some time was given, therefore, to supplementing the collection of fossils taken in 1903 and 1904. New species were obtained and many that had been collected before were found in other localities.

From Fort Hope, a H. B. C. post on Eabemet lake near the Albany river, the ordinary Indian route was followed to Lansdowne lake on the Attawapiskat river, whence a less frequented route was followed, leading from the northwest bay of the lake in a general northerly direction to the Winisk river, reaching it between Kanuchuan and Wapikopa lakes. This is not a very difficult route as, although it includes thirteen portages varying in length from a mile and a quarter to a few chains, there are long stretches of good water where canoe navigation is unimpeded. Leaving the bay above referred to by a portage of thirty chains, two small lakes, Obashin and Wagabkedri, emptying into the Attawapiskat river, are crossed and the stream is followed upwards through several small lakes to a divide, over which is a portage of a little over half a mile leading to a small lake at the head of one of the southern tributaries of the Winisk river. This small river is followed downwards, northeasterly, through two small lakes to the larger Mameigwess lake, eight miles long and deeply indented. It is shallow throughout, and with boulder-strewn bottom and many large and small islands. The surrounding forest of spruces, tamaracks and poplars is about eighty years old, the trees averaging not more than ten inches in diameter at the stump. Joined to Mameigwess by a short narrows is a lake five miles long and quite narrow, from the north end of which the stream flows off to the Winisk river, whence the route cuts across through a number of small lakes to a stream entering one of the southern channels of the Winisk below Wapikopa lake.

Biotite-granite gneisses, with a few hornblende gneisses, varying in attitude from nearly flat to quite vertical, are the prevailing rocks, varied only, about seven miles north of Attawapiskat lake, by a three-mile belt of altered diorites and chloritic and hornblende schists. The Winisk river was then followed up for forty miles to Nibinamik lake, biotite gneisses being the only exposures seen, with the exception of a small area near the foot of Wapikopa lake, of pyroxene granite, with markedly porphyritic crystals of orthoclase, probably a much later intrusion. A few days were spent in tracing out more closely a body of intrusive hypersthene-gabbro, noted last year, which, examined in thin section by Dr. Barlow, proved to be practically identical with the nickel-bearing intrusive of Sudbury. These rocks were found to cover quite an extensive area just south of the Winisk river and their occurrence here is interesting from an economic point of view on the reasonable chance of their containing the nickel bearing minerals of the Sudbury area. In the cursory examination possible, however, no nickel or copper sulphides were found.

From Nibinamik lake upwards the course of the river lies in a general westerly direction with southerly bends here and there. It is characterized by long stretches of stiff current and rapids connecting wide-spreading lake expansions. Few exposures of rock protrude through the cover of drift ; those that are seen are biotite gneisses. Green forest extends all along the river with only rare and small areas of recent brule. The forest generally averages eighty years in age with considerable areas of about forty years growth. Much of the timber is from one foot to fifteen inches at the stump, spruces, tamaracks and poplars being the principal trees.

At the foot of Wunnummin lake, twenty five miles above Nibinamik, a micrometer survey was started for the purpose of more accurately defining this large lake, which is roughly represented on all the older maps, and to make a connexion between it and Trout lake at the head of Fawn river. The lake was found to be twenty-six miles long and in places five to eight miles wide with bays extending off at various angles. At the outlet, and northwards for two miles biotite gneisses only are seen, succeeded northerly by schists and diorites followed by heavy beds of conglomerate holding large boulders of a highly quartzose biotite granite. These rocks occur in a belt crossing the lake in a direction about N. 70° E. and closely resemble the northern part of the Minnitaki Keewatin area, as exposed at and near Abram lake. The main channel of the Winisk river was then followed as far as Misamikwash (Big-Beaver-house) lake, a distance of twenty-four miles. In general character it remains the same alternation of lake-like expansions with connecting stretches of swift water. The few rock exposures seen along this part of the river were biotite gneisses. The surface is largely drift covered, the river in many places showing cut banks of sand from ten to twenty feet high ; it is rarely burnt, and the forest growth along and near the banks of the river is of good size.

Above Big Beaver-house lake the river divides into two main branches, the Pipestone, coming from the south and the Root river, from the west.

Ascending the northeasterly bay of Beaver-house lake to its head, it was found that the water was flowing out, and subsequent exploration showed that the outflowing stream was the headwaters of the west branch of the Winisk river, coming into that river again two hundred and thirty miles below at Asheweigkeiegen, one hundred and forty miles from the sea. An island is thus formed one hundred and thirty miles long and, where the two streams are farthest apart, seventy-five miles wide.

The route across to Trout lake from the Winisk is somewhat difficult on account of the small size and quick descent of the stream to be traversed. The outflowing stream from Beaver-house lake, the Asheweig, was followed, through several lake expansions and down long stretches of river with many rapids, for forty-seven miles to a small lake (Sturgeon lake of Dawson Brothers map of Manitoba, Keewatin, &c. 1880) into which a tributary comes from the west, carrying so little water as to be difficult of navigation by large canoes. This stream was followed upwards in a westerly direction for twelve miles, where a divide is crossed and another small stream, with many shallow rapids, leads to Trout lake. About half of the country traversed on this route has been burned within the past ten years and the remaining green forest portion shows trees of but small size.

Biotite gneisses are met with in occasional exposures, varied only by one small belt of hornblende schists, representing, doubtless, the tapering end of a Keewatin belt.

Biotite gneisses only are seen all about the southeast shores of Trout lake, well foliated and lying at low angles. The water of the lake is clear and cold and lake trout (*Salvelinus nemoycush*) were caught in good numbers by trolling.

Returning from Trout lake, in order to avoid the very shallow streams already traversed, a portage route was taken, leading by a number of long portages between small lakes lying in low swampy land, across to the inlet of Sturgeon lake.

From Sturgeon lake the Asheweig or West Winisk was followed downwards for thirty-three miles, the river for that distance being a succession of lake-like expansions. The connecting stretches are almost continuous rapids which may generally, however, be run, even by loaded canoes. The few portages made were in every case over level or slightly rolling sand and clay land with a deep covering of moss and a sparse growth of small spruces and tamaracks.

Leaving the Asheweig at a lake where its course turns abruptly northward, a portage of half a mile, over a low divide, led to a stream of considerable volume, flowing southwesterly, probably into Wunnummin lake. This stream, which proved to be, like the most of those already referred to in this district, an alternation of quiet water stretches, lake expansions and shallow, bouldery rapids, was followed upwards on a southeasterly course for twenty miles, to a small lake from which a series of small lakes and portages afford a route to a large brook coming from the west and flowing southerly into the Winisk river. The same recurrence of lake and rapid marks the course of this stream, the lakes being generally but a few miles in diameter though one, of irregular outline, has a length of ten miles.

The only rocks seen on this northern traverse were biotite gneisses, though, owing to absence of rock exposures along considerable portions, it cannot be asserted that the conglomerate and schist belt of Wunnummin lake does not extend, as would be expected, across the section explored. Gaining the Winisk river six miles above Nibinamik lake, the route passed over on the way in was again followed, with short digressions, to Fort Hope.

The timber over the whole area explored is for the most part of small size though, along the banks of the Winisk river and south of that river there are considerable areas of spruces, poplars and white birches reaching diameters, at the stump, of from one foot to fifteen inches. The country to the north of the Winisk, crossed on the way back from Trout lake supports, however, a forest growth chiefly of spruces and tamaracks that are seldom larger than eight to ten inches at the stump.

It will be seen from the foregoing description that by far the larger part of the area covered during the summer is occupied by Archæan gneisses. These rocks have, in a broad sense, a foliation trending about N. 70° E. but with abundant minor crumpling and large portions that lie nearly flat with a banded, stratiform character. The belts of Keewatin that are crossed at intervals when travelling north are much smaller in extent than the gneisses, to whose general trend they broadly conform. In general character and relationship to the gneisses they are quite similar to the belts of these rocks, so often described, in Northern Ontario. The whole district shows the effect of a general glaciation by an ice-sheet moving 20° to 30° west of south. The drift deposits are in many places comparatively heavy and to the direction of the Morainic ridges of gravel and boulders is due the frequent northeast, southwest trend of so many of the rivers and lakes. The highest hills seen were composed of unstratified gravel and boulders ; a very remarkable one is situated twelve or fifteen miles to the south of Wunnummin lake. It is a perfectly isolated conical elevation rising, perhaps, three hundred feet above the general level. This hill was not seen at close range, but the Indians agree that it shows only gravel and boulders to the summit. Similar eminences were described in last year's summary report as occurring along the upper waters of the Attawapiskat, and Mr. C. Camsell, in the same report, refers to others a little farther west, just south of Trout lake.

The only inhabitants of the district explored are Ojibway and Swampy-Cree Indians who trade their catch of furs with the Hudson's Bay Company at Trout lake and Fort Hope posts. In summer, bands of these Indians, encamped on the shores of the larger lakes, subsist upon fish taken in their nets, which diet is varied only by an occasional grouse, duck or hare. Wild rice is not found in any of the lakes so that they lack the autumn substitute for flour of the more southerly tribes, and berries are not plentiful enough to form any considerable part of their cuisine. A few have built log huts at their winter quarters with fireplaces and chimneys built of wicker and mud, but the majority still content themselves with the teepee built of poles and covered with birch bark or, in the case of the more northern families, with moss, cut out in blocks just as the Eskimos cut snow. During the winter they are engaged in hunting and live mainly upon hares and fish ; in the spring, camped close to a rapid on one of the larger streams, they live on fish, principally carp, caught automatically by a michiken or fish-weir, crossing the stream at the rapid.

The tracks of a few moose were seen between the Attawapiskat and Winisk rivers, but this is practically their northern limit in this longitude as, in the country to the north of the Winisk, the bushes on which they commonly browse are scarce or altogether wanting. The fur-bearing animals generally found in this latitude are all fairly abundant, with the exception of beavers, whose food trees are generally scarce over the muskeg areas.

Sturgeon are abundant in many of the lakes and rivers, and whitefish, lake-trout, doré and pike are found wherever the conditions are favourable.

From Fort Hope the route out by the Albany river and Lac Seul was taken, and it was found that transportation companies, in anticipation of the freight and passenger traffic arising out of the construction of the Grand Trunk Pacific railroad, had already two small steamers, on Sandy lake and one larger one on the route across Minitaki lake and down the English river. In low water this steamboat could only reach the outlet of Minitaki, but a dam, that would raise the water two feet, would probably suffice to flood out both the small rapid at the foot of Pelican lake and that at the foot of Abram lake, making a channel, deep enough for small steamers, as far as Pelican fall, a distance of thirty-nine miles from the end of the team road at Sandy lake. Ottawa was reached early in October.

The Lake Superior Region between the Pic and Nipigon Rivers.

Mr. W. H. Collins.

I spent the past field season in making exploratory surveys and a geological reconnaissance of a portion of the Archæan region north of Lake Superior. I was assisted in the work by Mr. H. C. Cooke. The area explored is rudely triangular, being enclosed by the shore of Lake Superior from Heron Bay to Mazokama, the Pic river and the Height-of-Land. It extends 80 miles along Lake Superior and northward 50 miles. Throughout, it is a peneplain of rounded hills of crystalline rocks 300 to 400 feet high, terminating abruptly along the south. Soils are scantily distributed, the old rocks being exposed, except in the depressions and river valleys.

Surveys.—Surveys of the principal streams and canoe routes, including the Little Pic, Steel, Black, Pays Plat and Gravel rivers, were made with the aid of a micrometer telescope and compass, the whole distance measured being 337 miles. Where the country was accessible only in light canoes or by overland travel, traverses were substituted and about seventy miles were covered in this manner.

Drainage.—From the Pic river to the basin of Lake Nipigon, the distance between the Height-of-Land and the shore of Lake Superior decreases from fifty to twenty miles, although the altitude of the former, which is about 450 feet above that of the lake, varies but slightly. Consequently, all the rivers on this slope are small and swift, becoming progressively more so from east to west. All rise among the multitude of small lakes that lie scattered over the level country forming the Height-of-Land and, in their upper portions, are sluggish, spilling from one natural depression to another until the region of lacustrine deposits is reached. These deposits, whose levels are approximately 250 feet above the present lake level, extend on the Steel river a distance of twenty-three miles inland and have been readily cut down by river action to form evenly graded and monotonous beds. Through such formations the streams are shallow, rapid and meandering. Just before entering Lake Superior, both Black and Steel rivers descend in rapids and falls a distance of nearly 200 feet, affording excellent water-power within easy reach of the railway.

Geology.—Geologically, the country was found to consist almost entirely of Archæan granites, gneisses and schists, penetrated by igneous granites, syenites, diabases and diorites of later age. A band of green schists, bearing lithological resemblance to the Keewatin rocks, follows the coast westward nearly to Rossport. North of this lies a complex of gneiss, characterized by a friable biotite schist and penetrated by dikes and small areas of very coarse acid granite and a few large diabase dikes. An interesting area of nepheline and augite syenites extends from Peninsula to Middleton on the C.P. railway and northward about four miles. Farther west, from Jackfish to the neighbourhood of Gurney, is a larger area of granite varying to syenite. At the western end of the triangle, red, calcareous shales of considerable thickness lie horizontally and unconformably upon the Archæan, and are in turn covered by a thick cap of diabase.

The terraces of post-glacial clays and sands already mentioned partially fill most of the river valleys, affording some patches of agricultural land. These are finely bedded and fossiliferous in places. The northern portion is partly covered by glacial débris and the exposed rocks show glacial phenomena abundantly. Morainic ridges were observed south of Kagianogama lake.

Minerals.—Economic minerals occur in considerable variety but rarely in paying quantities. A black, ferriferous sphalerite occurring as irregular bodies in diorite, has been obtained at the Zenith mine near Rossport, but mining operations are temporarily suspended. This area of diorite, which is about three miles across, contains blende of similar character at other points. Gold has been mined with moderate success on the Ursa Major and Empress properties, near Jackfish. Limonite was observed filling some small veins in granite a few miles west of Rossport, and magnetite occurs in a biotite schist on Caribou lake just north of the Zenith mine. Magnetite also occurs as thin layers in black schist near Schreiber and as magnetic sands at points distributed over the whole area. The magnetite-bearing segregations near Middleton are probably valueless, owing to the high percentage of titanium. Pyrite and pyrrhotite occur at various points in the hornblende and green schists near Lake Superior.

Forests.—The forests have been destroyed over a large portion of the area explored, especially in the vicinity of the railway, and are now replaced by second growths of poplar. The old forest contains cedar, spruce, tamarack, poplar and both white and yellow birch, the latter being abundant, although quite rare a short distance farther north. Growth is comparatively rapid and trunks of yellow birch twenty inches in diameter were observed. Along the Pic, Pays Plat and Gravel rivers a considerable quantity of timber has been removed in the past, as evidenced by wood roads and choppings.

I wish to convey my thanks to Mr. H. C. Cooke, of Toronto, for assistance given in the field, and to Mr. Joseph Miller, of Heron bay and to many gentlemen of Rossport, Jackfish and Middleton for various kindnesses.

W. H. COLLINS.

THE REGION BETWEEN LAKE TEMAGAMI AND SPANISH RIVER.

Mr. W. J. Wilson.

I received instructions from you to prepare a geological map of sheet No. 139 of the Ontario series, and to write a report on the same. This sheet lies adjacent to and west of the Lake Timiskaming sheet and north of the Sudbury sheet. It is seventy-two miles long and forty-eight miles wide, containing 3,456 square miles. As very little topographical work has been done in this large area it is necessary to make a survey of the lakes and rivers examined in order to fix the geological boundaries. The area contained in this sheet is covered with a dense forest and abounds in lakes and streams, most of which are difficult of access, so that the progress of the work is comparatively slow. It will, therefore, take at least two more summers to finish the surveys, and as a full report will be written to accompany the completed map, only an outline of the work done during the summer will be given in this report.

I left Ottawa June 1st, and reached Temagami the same day. While there I studied the iron range on the northeast arm of Temagami lake, and spent a day at Cobalt noting the rocks and ores of that locality. On June 6th I arrived at the Hudson's Bay Company's post on Bear island, Temagami lake, where I procured my supplies for the summer's work, and the next day started for Lady Evelyn lake accompanied by Mr. George L. Cameron, of Mount Albert, Ontario, as assistant, and three canoemen. The survey was commenced at a small island in the northwest part of Lady Evelyn lake, and continued west through Willow Island lake, and up Lady Evelyn river to its source in Apex, or Kettle Stone lake, whence it was carried north into Smoothwater or White Beaver lake, and down the Montreal river to the first portage, a distance of six miles from the lake. Returning to Apex lake, the canoe route southwest to the Sturgeon river, at the mouth of Stull branch, was surveyed, passing through ten small lakes and over ten portages. Dr. Bell surveyed this route in 1876. From this point the survey was continued down the Sturgeon to the mouth of the Obabika river.

Having procured fresh supplies, the Sturgeon river was ascended for five miles above the mouth of the Obabika, from which point I turned north on a canoe route to Lady Evelyn river. This route runs roughly parallel to that already surveyed from Apex lake southward. It is rarely used, and proved to be very difficult. The portage from the Sturgeon is more than three miles long and had to be cut out the greater part of the way. At the north end it connects with a series of lakes and portages, many of which have not appeared on any published map. The largest of these lakes, Florence, is six miles long and empties into Lake Evelyn river by a sluggish stream a mile and a half long, at the mouth of which the survey was tied to that of Lady Evelyn river.

I again went to the Hudson's Bay Company's post for supplies, but found great difficulty in getting a guide, the large number of tourists having engaged all the available men. It was, therefore, necessary to obtain a smaller canoe and continue the work with my assistant and only two canoemen. I went west through Obabika lake and surveyed the route from the outlet of Round lake, down the Obabika river to the Sturgeon, connecting with my former survey of this river. I carried the survey down the Sturgeon to the south boundary of the sheet, and came back ascending the river to a point about four miles above the mouth of the Obabika, where a portage leads southwest to a small lake. This is the beginning of a canoe route to Wanapitei lake, which I followed as far as Chinigoochichi lake. Having surveyed the northern part of this lake I went northeast to the Sturgeon river through six lakes, three of which are of considerable size. The last portage on this route joins the Sturgeon river about eighteen miles above the mouth of the Obabika. The Indians frequently use this circuitous route to avoid the rapids and shoals of the Sturgeon.

At the end of this trip, Mr. Cameron having returned home, I left the Hudson's Bay Company's post with three canoemen and followed the usual canoe route to Wanapitei lake via Gull lake, the Sturgeon river and Maskinonge lake. The survey of the upper Wanapitei river was begun at its mouth in Wanapitei lake and continued up to the crossing of Niven's meridian line, 1896, and five miles farther west. Welcome lake, which is crossed by Niven's line five miles south of the Wanapitei river, was also surveyed.

The valleys of Lady Evelyn, Sturgeon and Wanapitei rivers are fairly deep but in most places narrow, having hills rising to a height of 200 feet or more a short distance back. There are two falls on Lady Evelyn river the highest being about ninety feet. This is over a bare quartzite cliff and would make a good water power. There are also numerous rapids and shoals which impede navigation and make travel impossible for loaded canoes in low water. The Sturgeon river is rapid and rough in its upper part and has many falls that could be utilized for water powers. The best of these is Kettle fall which is over forty feet high. The upper Wanapitei river from its mouth to near the northern boundary of the township of Aylmer is deep and of moderate current; above this, for twenty miles, it is almost one continuous rapid and is so shallow that we sometimes had to drag the canoes. Above the stream from Welcome lake the river is deep and winding and flows through a level sandy-clay soil.

The geology of the area examined is too complex to admit of a detailed description until after the collected specimens have been thoroughly examined. In general, the rocks resemble closely those lying to the east in the western part of the Lake Timiskaming sheet. They consist of Laurentian, Keewatin and Huronian with large intrusive masses of new greenstone. White, reddish and greenish quartzites are found occupying large areas on all the routes examined and form many of the rounded hills, which abound over the whole country, while hills composed of the new greenstone frequently have one side an almost perpendicular cliff rising 100 or 200 feet high. Syenite and gneiss were noted on the Sturgeon river at Paul, or Ghoul, lake and Twin falls, and on the Wanapitei river for some miles above and below the mouth of the stream from Burwash lake, 'Breccia Conglomerate' occurs in several places between the Sturgeon and Lady Evelyn rivers and north of Chinigoochichi lake. A band of calcareous slate was seen on Welcome lake.

The greater part of the country is covered with an old forest growth and no heavy fires have over-run any part of it within the past fifty years. White, red and Banksian pine and spruce are plentiful and grow to a large size. Some of the white pine measure ten feet in circumference five feet from the ground. Poplar, canoe-birch and cedar are also common.

Good speckled trout abound in Lady Evelyn river, and lake trout, pike, pickerel, bass and whitefish are common in nearly all the rivers and lakes.

Moose are very abundant. As many as fifty were seen during the summer and their trails were noted along the rivers and lakes. Only a few red deer were observed. Wolves were frequently heard in the valley of the Sturgeon river.

The red and white pine over a large area show the effects of some blighting influence; from one quarter to one half of the foliage of many trees has been killed and turned reddish or grayish-brown. Probably this is caused either by the larvæ of some insect similar to the larch sawfly, which has killed all the tamarack in the district or to a fungus blight Whatever the cause, it will, if continued for a few years, result in the destruction of a vast amount of valuable timber.

I am indebted to Mr. H. G. Woods of the Hudson's Bay Company for much valuable assistance in the prosecution of the work.

The Muskoka District.

Dr. T. L. Walker.

In accordance with instructions received from the Director of the Geological Survey of Canada, I left Toronto on the 21st of June, 1905, for Penetanguishene with a view to continuing the geological survey of the Muskoka sheet. The field-season continued from that date until the 28th of September.

The Muskoka sheet comprises parts of the districts of Muskoka and Parry Sound, extending from the Georgian Bay shore eastward to the Haliburton sheet, a distance of more than seventy miles from east to west. It was hoped at the beginning of the field season of 1905 that I should be able to supplement the observations already made in this district by A. Murray, Dr. Bell and other geologists, so as to make it possible to prepare the report and map of the sheet for publication. Every effort was put forth during the short field-season, but I fear that as yet we possess only an outline on which considerable detailed work should be expended.

Throughout the whole of the field season I had the assistance of Mr. R. E. Hore, B.A., of Toronto. Later the party was increased by the arrival of Mr. W. D. Herridge, of Ottawa, and Mr. J. D. Wood, of Toronto, the latter gentleman as a volunteer worker. While planning at Penetanguishene for the coast trip in the sail-boat, I secured the services of Jean Bissette, who was the only white man with Alexander Murray's party while exploring the Muskosh in 1853. To all of these assistants I am indebted for zeal and enthusiasm in the prosecution of the work.

The first three weeks of the season were spent in examining the shore and islands of Georgian bay. This work was carried on while travelling in a sail-boat. In this way we were able to carry on the work in a manner which would have been impossible for us had we been limited to canoes as a means of transportation. The shore journey was undertaken at the beginning of the season so as to give an opportunity of observing the splendid rock exposures along both the mainland and the islands, in this way obtaining the benefit of a satisfactory classification of the chief rock types. From the 15th of July to the 6th of September we travelled by canoes, starting from Port Severn; after examining the shore line in detail as far as Franklin island, we proceeded inland to the Muskoka lakes and finally southward to Sparrow lake and the Severn river. During this tour many lakes and rivers were traversed, but, owing to our desire to secure an outline of the whole of the Muskoka sheet, many of the water courses have yet to be examined before the completion of the work. The last three weeks were devoted to overland exploration, travelling most of the time by road, using a team and wagon for the transportation of our impedimenta.

The forest growth varies from spruce and tamarack on the flat wet land, white and red pine, birch and hemlock on dry sandy soil, to beech, maple, birch and hemlock on dry land, containing considerable clay and covered with a dark humus. Unfortunately for the Province of Ontario the more valuable timber, pine particularly, has been harvested by the lumberman, cleared away by settlers or destroyed wholesale by fires, many of which might have been prevented had we earlier learned the value of our splendid forest land.

The whole of the region examined has been covered by an ice sheet and glaciated. The general movement, as indicated by the striæ, was from N. 15 E. to N. 25 E. Frequently the smooth and rounded rock surface is quite free from covering, though, as a rule, the glacial drift forms a mantle of considerable thickness.

Apart from recent formations the rocks of the district are as follows :—

1. Palæozoic-Trenton.
2. Gabbro intrusions.
3. Anorthosite intrusions.
4. Granitoid Gneiss.
5. Grenville Series.

These rocks are mostly limestone, occurring along the southwestern margin of the sheet, comprising Christian, Hope, Beckwith and Quarry islands as well as some portions of the mainland from the town of Midland westward. These rocks are quite undisturbed and rest unconformably on the eroded surfaces of the banded rocks of group 4. They have not been examined in detail, nor have the fossils collected from them been determined.

Two important areas of these rocks have been discovered and mapped. One of them comprises the little peninsula at Moores Point in the township of Baxter, the second the northeastern part of Parry island. In both of these there is evidence that they are intrusive and of an age more recent than either groups 4 or 5. Considerable variety in petrological composition and structure has been observed. "Mines" of copper are reported to be associated with both of these massifs.

Plagioclase rocks (Anorthosites) occur along the western sides of Parry island; on the shore of the long narrow Twelve Mile bay in Freeman township; on the Severn river, a short distance east of Port Severn, and in other places. Normally the anorthosite is a white rock with small quantities of the dark mineral arranged in such a way as to give rise to a faint banded structure. Its associates are usually gneisses of the Grenville series, so that the impression is made that this rock is an early igneous constituent of the gneiss complex, consisting of schists derived by the metamorphism of sediments.

A very common rock in many parts of the Muskoka district is a more or less banded pinkish granite or granitoid gneiss. It may become almost as massive as a granite but this massive portion is usually surrounded by better banded types. Such typical massive centres were observed—(1) On the islands and shores of the northern part of Lake Joseph. (2) On the islands and shores of the northern half of Parry sound. (3) On Beausoleil and adjacent islands, and (4) on the islands to the north of the entrance to Go-Home bay. The commonest type of rock is composed almost entirely of pink feldspar, (microcline or orthoclase), glassy quartz, with smaller proportions of garnet, hornblende and biotite. The dark minerals are arranged in bands, usually making the rock assume the banded structure of gneiss. In mineralogical composition these rocks are orthoschists metamorphosed or pressed igneous types. They usually dip under the rocks of the Grenville series which are probably the oldest of the rocks referred to in this report.

These rocks make up the major part of the Muskoka sheet. They are composed of crystalline limestones, graphitic schists, sometimes with sillimanite and rose-tinted garnet, granular grey gneiss and dark hornblendic rock usually schistose but sometimes massive. The Grenville series appears to present a metamorphosed complex of rock-sediments of varying chemical composition with igneous intrusions, dikes, or flows, which were associated with them prior to the metamorphism. The rocks of this series are frequently cut by pegmatite dikes, the only variety of dike met with in the region. This freedom from intrusive dikes seems to indicate that since the metamorphism of the Grenville series the region has experienced a very long period free from great earth movements.

The chief interest, so far as economic minerals are concerned, centres in the region within a radius of ten miles of Parry sound. Inside this area, copper and gold prospects are frequently associated with the rocks of the Grenville series. The best representative of this class of deposit is the Gowan mine near Parry sound. Farther east, mica has been discovered in various parts of the township of Christie, but as yet no actual mining is being carried on.

Niagara Falls and Niagara District.

Dr. J. W. Spencer.

Many years ago I had the opportunity of making a long detailed study of a portion of the Niagara peninsula, which was published under the title of 'Geology of the Region about the Western End of Lake Ontario.' These investigations led to the study of the physics of Niagara river, showing that it was modern and not preglacial.

Another investigation, though not immediately in the Niagara peninsula, was of the greatest importance in its bearing upon Niagara Falls. In 1888 I traced, from the foot of Lake Huron, the Algonquin beach, which I so named, around Balsam lake, and found that this beach rose from near the lake level at the present outlet of Lake Huron to a considerable height at Balsam lake, where it was breached by a former outlet into the Trent valley. This discovery more than any other has affected the determination of the recession of Niagara Falls, for it showed that, until lately, Niagara Falls received only the drainage of the Erie basin. I also found a lower terrace much below the outlet of Lake Huron, which Mr. F. B. Taylor connected with Lake Nipissing, where there was a later and lower outlet.

Later, in 1894, I published the relationship of the Iroquois beach at the mouth of the Niagara gorge to the Falls, and showed that the river descended a much less height then than at the present time. I also found a fragment of the floor of the river of that time at Foster's Flats, showing that the Falls receded over three miles, while the descent of the river was low and the volume of water much less than now. These and other features enabled me to make an entirely new departure in calculating the age of the Falls based upon the changing physics of the river, which, from the data then available, placed them at 32,000 years. But the physical structure in the region of the Whirlpool, for more than two miles in length, practically defied investigation.

A new interest had arisen in the Falls, from the utilization of the water for power purposes on the one hand, and the preservation of the scenery of Niagara on the other. One good representation of the position of the Falls in 1819 is preserved, but it is not sufficiently accurate for exact comparison in determining the recession. In 1842 Prof. James Hall laid the foundation of correct investigation by making a trigonometrical survey. Again, in 1875, 1886 and 1890 surveys were made ; all of them by officials of the State of New York or of the United States, and none by Canada. In October, 1904, I commenced a survey, with the assistance of engineers from the Electrical Development Company, of the Canadia n Falls, the recession of the American Falls being immaterial on account of its slowness. This was the first Canadian survey, and the fifth in all that had been undertaken. In June last, I began the revision of the entire work of the changing physics of the river. The new features which developed occupied very much more time than any one could have anticipated, but with almost daily discoveries. I have spent about five months in the field, engaged in this work.

In my earlier writings on Niagara Falls, the discharge of the river was based upon the old determinations of the United States engineers. These, however, are now superseded by very much more accurate ones that have lately been made. The various power companies also afforded opportunities of detailed investigation which would not have been obtainable at a later date on account of the departure of the engineers who had made the measurements.

In June, the weather and the direction of the wind were unfavourable for the re survey of the crest of the Falls, but this was accomplished in August, and revised in October. In the latter part of November, an important rock-fall occurred which will be shown, approximately, on the map. The result of this re-survey of the Falls shows that during the years from 1890 to 1905 the recession has been only about one-half of that of the previous fifteen years. Only a small portion of this reduction can be attributed to the use of the water on the American side. Part of it is unquestionably due to the shape of the crest producing a greater resistance, for it has been found that the rate of recession is far from uniform, except over averages of long periods. But, by the study of the level of Lake Erie, records of which have been kept, and of the discharge corresponding to the changing levels, it has been found that this has been greatly reduced during these later years. This has been one of the causes of the lessening of the rate of recession of the Falls.

The recession of the Falls shows that it is not merely a question of the undermining of the hard, overhanging limestones by the removal of the shale beneath, but that the limestones are breached along joints which are opened and are finally wedged off, thus allowing the waters to strike upon lower ledges, as is shown in the rock-fall of November, 1905, producing one of the finest effects of the cataract. A feature of the recession is the alternating of a broad or flat crescent with one having a wedge-shaped apex. Since 1890, about one acre of the rock at the brink of the Falls has been removed.

The width of the river between Goat island and a fragment of the old shore line at Table Rock is about 1,200 feet. For purposes of computation this may be taken as the breadth of the gorge. If we take the average for the recession or lengthening of the gorge, then we find that during the last fifteen years it amounts to 2·2 feet per annum. Between 1890 and 1875 the annual average was 5·4 feet; between 1875 and 1842 it was 4·5 feet per annum; and between 1842 and 1819 it was apparently much more. This represents an average since 1842 of 4·2 feet per annum. Since 1842 the centre of the Falls has receded 285 feet, all of which was effected before 1886, since which time the processes of recession have been expended in widening the crescent.

Less than one-tenth of the total discharge of Niagara passes over the American Falls; the remainder coming down through the Canadian channel between Goat island and Queen Victoria park. At the first cascade near the head of Goat island, the ledge of rock, apparently uniform in depth, extends nearly to the Canadian shore and determines the height or level of the river, which is ten times as wide as the channel on the eastern side of Goat island. On account of this ridge, the power companies that take their water below it will produce little or no effect in disturbing the level of the river above; or, in other words, lowering the water on the New York side. But one of the power companies takes its water at the end of this ridge and has a franchise for more than double that of the other companies. This water when used must draw off a large volume of water from the New York side, and will also affect the whole discharge from the Canadian Falls, as indeed will also the other power companies. From the determinations of the engineers, it is found that the discharge of Niagara Falls is reduced by about 23,200 cubic feet per second when Lake Erie at Buffalo is lowered one foot. During the latter part of June, the water was high and the discharge over Goat island shelf made a contiuuous sheet of water; in August it was a few inches lower, and over portions of the shelf, the sheet was reduced to simply strings of water. This will give some idea, in advance, of the effect of the diversion of the water from the river to the various tunnels. The reduction of ten or fifteen per cent in the discharge in the river will narrow the channel and divert the water from its shallower portions. To modify the effect, the Canadian side of the Falls has been reduced by several hundred feet.

In the course of the survey, I observed what had generally escaped the attention of previous surveyors. The International Boundary is not a changeable feature, but was established by the International Commissioners in 1819. The boundary line has never been shown correctly on any map, that I have seen, except that published by the U. S. Lighthouse Board. This line is distant from Goat island about 300 feet, so that it places all but one horn of the crescent of the Canadian Falls in Canadian territory, as is also the river for some distance above the cataract. This leaves the preservation of the falls largely under the jurisdiction of Canada. That this line is not far from the deep part of the channel is established by soundings (192 feet), the centre of the river below the falls being very much more shallow (84 feet) than the deep channel close under Goat island shelf. This feature was not discovered until I made the first soundings ever undertaken.

Another feature of the investigation was one very difficult of execution. This was the soundings of the river in the gorge at various points. A number of soundings had been made by the United States Lake Survey in the vicinity of the Upper Steel Arch Bridge, or at the crossing of the 'Maid of the Mist', but none had been taken in front of the American Falls, or above it to the crescent. I carried my soundings much farther than the line to which the 'Maid of the Mist' usually runs, and also nearly as far down as it is safe to navigate the river above Whirlpool rapids. Again, a line of soundings across the Whirlpool was obtained which required a movable cable to be carried across the gorge from which the sounding apparatus was operated. As the Whirlpool contains so many logs, which caught the wire when it touched the water, the difficulties were very great; but the soundings were eventually successful. The over-currents of the river here are not extraordinary, but I found the most remarkable under-currents, so that nearly all the water describes a spiral form and passes out as under-currents. Farther soundings were made across the river just below the outlet of the Whirlpool. Here the cable broke three times; once with peril to the men in the boat. All the depths were obtained by the Tanner-Blish sounding tubes, which record the weight of the superincumbent water and are unaffected by the velocity of the river. This was the only practicable method of ascertaining the depths.

From the soundings in the gorge it is found that the depth of the river varies greatly and shows many remarkable features. But it would be premature to announce these results until the significance of the whole can be presented. Thus, in the centre of the cauldron beneath the Falls, and as near the Falls as a boat dare go, the depth was found to be 84 feet; while close under Goat island shelf it reaches the extraordinary depth of 192 feet. This feature by itself becomes only a curiosity, and is inexplicable unless the subject is treated as a whole. However, I may elsewhere somewhat enlarge upon this subject.

Professor Hall's survey in 1842 shows the crest of the Falls to be an unbroken crescent; the U. S. Lake survey soundings in 1875 would suggest that the middle of the river was deepest; Prof. Woodward's measurements in 1886, showing the apex at one side of the crescent, would be suggestive had not the two previous surveys shown the outline of the Falls to be nearly regular. Therefore it was a surprise to find this extraordinary depth close upon one side of the cauldron. Turning back to the form of the Canadian Falls in 1819, we find a very deep V-shaped incision in the crest line located near Goat island shelf, showing that there the deepest channel was to be found. This feature was subsequently shown in repetition from 1886 to 1890. Accordingly this deep sounding occurs in the line where the changing apex of the Falls has reappeared. As yet, however, it would be bold to assert that even near the present apex the channel is being excavated to this phenomenal depth.

It is generally known that at the end of the Whirlpool a buried channel occurred, which, to a great extent, gave rise to the Whirlpool. As the ground is levelled over in this region by drift, it could only be studied at the two ends—at the Whirlpool and in St. David's valley, where drift of greater depth occurs. In the apparent valley above St. David's I found rock at 250 feet above Lake Ontario, reducing the possibility of a buried channel to a breadth of not over one-third of a mile; also at some points where streams cross its edge the channel is exposed, showing it much farther east than had been supposed. Here the face of the rocks of the channel are highly glaciated, thus indicating its age. By well borings the western border was further established. At 1,140 feet east of the western wall I sunk a well and found it was within the channel. At another point about 630 feet from the western well I have sunk another well to a depth of about 230 feet, or to a point about 75 feet above the level of the whirlpool, without reaching rock. This is to a point below the gas bearing rocks. This work will be resumed to try to reach the bottom of the channel.

The air currents in the well, which were a remarkable feature, suggest that it is in proximity to crevices that would seem improbable outside of cavernous rock. Wherever the drift of this region is removed, a highly polished rock-surface is revealed, with the direction of glacial striae oblique both to the face of the Niagara escarpment and that of the gorge. While red, and sometimes blue, clay is found at the surface, the filling of the channel is made up largely of sands and more or less angular gravels which render boring very difficult, and no water wells can be obtained in the channel. At 186 feet below the surface, in the buried Whirlpool gorge, I found white spruce wood in a fair state of preservation. The drift here is a subject which has not been systematically studied by any one, and many new features have been added in this survey. On account of the character of the drift, there has been much uncertainty as to the correct boundary line of the Niagara limestone formation on the one hand, and the Corniferous limestones near Lake Erie on the other, with the intermediate Salina formation in the fundamental rock-surface below the drift.

From the study of the beaches, I first pointed out many years ago, the probable future extinction of Niagara Falls by the diversion of the waters into the Mississippi, and computed the time when the water of the river would be drained as far back as Buffalo, at several thousand years. The rate of the rise of the land is now challenged by the new observations, and even if these were correct, new features hitherto unobserved would so modify the results that probably much more than 5,000 years must elapse before Niagara will be diverted into the Mississippi.

My full report upon the subjects herein indicated must be lengthy, and as there has not been sufficient time to systematize the results, I must postpone publishing at this moment the undigested facts. Several discoveries of the greatest importance have been made, and much new light on the mode of recession of the Falls and their capabilities has been found.

As the natural gas of the Niagara peninsula comes principally from the Clinton and certain of the Medina beds which are dissected by the Niagara gorge, I have also given this subject consideration. These rock beds, while they come to the surface at the brow of the mountain, dip to the southward ; the precise direction will be given when the computations are made. They are at a considerable depth below the surface where the wells are most productive.

Including all my previous work in the region of the Great Lakes, the forthcoming report on the Niagara district is expected to be the most important. My former estimate of the age of Niagara must be increased. I have also, for the first time, satisfied myself to what point Niagara Falls had receded when Lake Huron first turned its waters into Lake Erie.

Certain terraces about the lakes have a most important bearing in explaining the physical changes of the Falls. All the work above indicated has been done instrumentally, so as to arrive at the most satisfactory results. The borings are still in progress and more additional revisions in the field will be necessary. But the final report is being prepared with the utmost rapidity and contains the results omitted here for the reasons above given. When published, these discoveries will greatly add to the knowledge of the geology of Niagara district and of the Falls.

It may be added that the water that passed over the Falls during its highest stage in May, 1905, reached 267,000 cubic feet per second ; during its lowest stage in February the discharge fell to 164,000 cubic feet per second. These figures would correspond to 4,900,000 gross horse power for the larger figure, and 3,021,000 gross horse power for February. But the total work done by the river between the two lakes will double this amount.

The Peterborough Sheet.

Mr. W. A. Johnston.

My instructions were to complete the geological survey of the Peterborough sheet. A considerable part of this sheet had already been surveyed. The remaing part included the townships of Murray, Seymour, Percy and Alnwick in Northumberland county; Dummer, Asphodel, Otonabee, Monaghan, Douro, Smith, Ennismore, Harvey and Galway in Peterboro' county; the northern part of Manvers and Cavan in Durham county and Emily, Ops, Fenelon, Verulam, Somerville, and the southern part of Lutterworth in Victoria county. Nearly all the roads in these townships were surveyed by means of a compass and a bicycle with cyclometer attached, and the different rock formations were mapped out as well as the overlying drift would permit.

Owing to the absence of roads, the central portion of the township of Galway was difficult of access. The main outlines of the different crystalline rocks, however, were fixed by making traverses across it. I proceeded to Campbellford on the 2nd of May and began work at the Hastings line, east of which the country had already been surveyed. The month of May was spent in Northumberland county. On June the 6th my assistant Benj. Tett, B. Sc., joined me. During the greater part of the summer we worked separately, and in this way a considerable area was covered in a comparatively short time. Mr. Tett's work was confined to the southwestern corner of the sheet, our work being connected up at several points. We returned to Ottawa on October 2nd.

Geological Description—Nearly the whole of Northumberland county is covered with drift which appears to be everywhere underlain by Trenton limestone with the exception of the northeast corner where the Black River formation comes in, resting on Laurentian gneiss. The Trenton limestone—usually in thin beds and containing an abundance of well-preserved fossils—forms the bed and banks of the Trent river, from Trenton to Healy falls, five miles above Campbellford. This formation was also seen in various places in the beds of creeks as far west as the village of Warkworth. From the upper end of Crow bay, a few miles above Campbellford, along the Crow river to the Hastings line, the Black River limestone rocks are exposed, resting on the Laurentian gneiss which appears at Allans Mills and at the Crow rapids. Westward from Northumberland county, roughly speaking, a line drawn from the village of Hastings through Lakefield and Fenelon falls to Balsam lake would define the boundaries of the Trenton on the southwest and the Black River on the northeast.

The dividing line between these Cambro-Silurian limestones and the Archæan rocks is very irregular and several outliers of Black River limestone occur to the north of the Trent valley chain of lakes in Harvey township, Peterboro' county. In this county, the contact with the Laurentian gneiss and amphibolite occurs along the south side of Stony lake and Deer lake, as far as Buckhorn, where it strikes northwest across Sandy lake to the north shore of Pidgeon lake. The islands of Stony lake are composed of Laurentian gneiss, banded with amphibolite.

In Victoria county the Black River limestone extends as far north as the village of Norland and east from there to Silver lake on the town line between Victoria and Peterboro' counties.

The northwesterly corner of the sheet is occupied principally by the limestones of the Grenville and Hastings series, with several comparatively large areas of the Fundamental gneiss. One of these areas occurs in the southeasterly portion of Galway township and another in the southeasterly part of Lutterworth and in the vicinity of Kinmount. In the central and westerly portion of Galway township a large area of crystalline limestone, interstratified with bands of gneiss, amphibolite and quartzite is developed. The general strike of these limestones is S. 30° W. with a dip of 30° towards the S. E. They frequently contain bands of bluish-black, partially altered, limestones, and limestone-conglomerates occur about the centre of the west line of Galway. In Lutterworth the gneiss predominates with several comparatively small areas of pure white crystalline limestone, which is more especially abundant around the southern end of Gull lake. About five miles south of Kinmount, a trap dike, striking north and south, cuts the crystalline limestones and interbanded gneiss, and, in several other places in Galway, small outcroppings of volcanic rocks were seen. The limestone is also invaded by numerous granite and pegmatite dikes.

DRIFT.

Nearly the whole of the country south of the Trent valley chain of lakes is covered with drift material. The northern part of Durham county is especially hilly. Nearly all the hills and ridges which have a general trend towards the southwest were found to be composed of boulder clay with a superficial covering of sand and gravel. Only occasionally are good gravel pits found like that near Fenelon Falls.

LITHOGRAPHIC STONE QUARRY.

The only quarry examined was the one situated slightly to the north of Burleigh Falls. From here a first-class lithographic building stone was being shipped to Burnt River station, on the Lindsay and Haliburton railway.

MINERALS.

Most of the mineral occurrences of this sheet have been already described. None of the mines were in operation.

CORUNDUM.

A still further occurrence of corundum in the corundum belt of Ontario was discovered by my assistant, Mr. Tett, on lot 12, concession iv, of the township of Lutterworth, in Victoria county. The corundum bearing rock here is a pink syenite, cutting the gneissic granite of the district, and occupies an irregularly shaped area of thirty or forty acres, throughout a considerable part of which corundum was found in more or less abundance. A small hill, over which the road from Kinmount to Norland passes, is especially rich in the mineral, and a considerable part of it would probably go 10% corundum. Associated with the corundum is a small amount of pearly mica or altered corundum and magnetite. This occurrence of corundum may prove valuable ; it is easily accessible, being only about five miles from Kinmount on the Lindsay and Haliburton railway.

COAL.

One of the places where coal was reported to have been discovered was visited, viz. : lot 4, concession 4 of Ennismore, Peterboro' county. A few pieces of coal had apparently been found in the side of a hill composed of sand and gravel. Not enough of it was seen to determine its character. No coal in place was seen.

The Cobalt Mining District.

Dr. Robert Bell.

This district has an area of about fifteen square miles and is situated on the line of the Timiskaming and Northern Ontario railway, its centre being three or four miles west of the northern part of Lake Timiskaming on the Ottawa river. Its surface is undulating, partly rocky and partly drift covered, and is well wooded. On the large scale, it has a generally even aspect and is interspersed with numerous small lakes.

The rocks of the district in general, provisionally classified with the sub-Huronian or Keewatin series, are mostly of igneous origin, consisting of granites, greenstones, agglomerates, volcanic tuffs, &c, and are favourable to the occurrence of metallic ores, should any veins exist among them. It was, therefore, considered to be only a matter of time in the evolution of the country from a state of wilderness, when important deposits of ores would be discovered anywhere among these rocks.

To the southward of the igneous rocks of the Cobalt district, quartzites, crystalline schists, &c., of Huronian age occur around Lake Temagami and southward, and still farther south quartzites of the same series, while still farther, in the same direction, several varieties of Laurentian gneiss are developed all the way to Lake Nipissing. To the northward of Cobalt, one large and several smaller inliers of unaltered, horizontal fossiliferous limestone of Niagara age rest upon the igneous and metamorphic series.

In 1887 and subsequent years, the writer made a geological reconnaissance of the region around Lakes Timiskaming and Temagami and westward. In November, 1905, and again in April, 1906, he visited the Cobalt mining district for the purpose of studying the rocks of this particular area and the modes of occurrence of the ores associated with them.

Native silver and its associated minerals were discovered early in the summer of 1903 by Messrs. McKinley and Darragh, at the southwest extremity of what is now called Cobalt lake. These men were then engaged in taking out ties for the new railway under construction. Having had some experience in prospecting, one of them, in breaking the rock at the southern angle of the lake, close to the right-of-way, discovered small pieces of a white metal embedded in it. On removing the moss and black loam in the vicinity, numerous small thin blackened plates of this metal were found. About the same time, native silver was recognized in a vein at the northeast end of Cobalt lake and some large and small rough blackened nuggets of the same metal were washed out of the earth on the outcrop of the vein. The construction of the railway was, therefore, the direct means of making the discovery of what is turning out to be an important mineral district. The "finds" above mentioned, however, attracted but little notice, as the men who made them were directing their attention to the discovery of copper ore and not thinking of silver, none of which had previously been found in this part of Canada, and they were not impressed with the possible significance of what they had found.

In November of the same year, the attention of Prof. W. G. Miller, Provincial Geologist of Ontario, was called to this discovery and he paid a visit to the locality, returning with specimens of the silver and its associated ores. As these had been found in only two or three spots at that time, Prof. Miller could not forsee the numerous discoveries, over a considerable area, which have since been made, but he thought that the prospect already located was distinctly promising.

I considered the discovery sufficiently important to have it thoroughly investigated by the Geological Survey, and accordingly I engaged Prof. Parks, of Toronto University, to undertake the work immediately on the close of his college duties the following spring. In the meantime, the Ontario Government had sent Prof. Miller to the same ground very early in the season, (about the beginning of March). After Prof. Parks had worked for some time on the same ground as Prof. Miller, the latter proposed a division of their operations, so as to avoid duplication. As it appeared that the silver-bearing district might extend a considerable distance to the northward, he suggested that Prof. Parks should explore in that direction, while he himself would operate to the southward.

At the present time, openings, showing more or less native silver, have been made in probably nearly a hundred different spots within the fifteen square miles above mentioned as comprising the productive silver district of Cobalt. With few exceptions, these openings have been made in what is locally called a "conglomerate," but which is more properly an agglomerate, containing numerous irregularly distributed angular and rounded fragments, mostly of gray and red granite, and of the porphyrite itself in a somewhat soft bluish and greenish gray matrix of hornblende porphyrite or porphyritic tuff. The fragments are seldom large, and they are generally very irregularly distributed, partly in bunches, but in other parts they are sparsely disseminated.

The agglomerate has a general horizontal aspect, but there appears to be little or no evidence of aqueous stratification in the agglomerate itself, or of the action of water in the arrangement of the fragments, which are scattered through the mass at all angles. The weathered surfaces have the character and appearance of a volcanic rock and not of a conglomerate. The fragmental character of this rock prevails at the surface throughout most of the silver-bearing area, but, in the deepest workings, it shows a tendency to become non-fragmental. The colours of fresh fractures are generally bluish and greenish gray, but at some localities the colour is a dirty drab and, on close inspection, this shows a mottled character of lighter and darker shades. It is doubtful if this agglomerate is equivalent to either the Lower or Upper slate conglomerate of the Huronian system north of the St. Mary river.

At some places in the district, the agglomerate passes into or includes fine grained gray or drab slaty rock, and at others gray arkose or greywacke, grading into a variety of impure quartzite. The total thickness of these rocks has not been ascertained. At the Larose mine, the upper stratum consists of about twenty-five feet of the fragmental agglomerate, underlain by an equal thickness of gray slate, which together form a cliff fifty feet high. The surface then slopes down from the foot of the cliff for thirty or forty feet to the collar of the shaft, which has been sunk on a group of small silver-bearing veins, separated from one another by the country-rock, and having an average width of four or five feet. At the time of my visit last November, this shaft had been sunk through the agglomerate to a depth of ninety feet, and a drift run for about 100 feet to the northeast and 350 feet to the southwest. The country-rock on either side of the vein was seen to carry metallic silver at many places throughout this length. At one point to the southwestward of the shaft, the vein-group bulges to a width of about twelve feet and shows distinct parallel veins in the roof of the drift. Within fifty feet of the southwestern extremity of the workings, at that date, the vein divided into two branches, both of which were rich in silver. During the winter the shaft was continued to a depth of 205 feet from the collar to the bottom of the sump, and at 200 feet, a tunnel was driven forty feet N. E. and 50 feet S. W. from the shaft. A winze was also sunk from the 90 to the 200 feet level, at a distance of 150 feet from the shaft. In the 200 feet level are two veins of calcite, separated by dark slaty country rock. This latter as well as the veins, is rich in native silver in the form of plates and rough nuggets. The rock breaks into lumpy schist-like fragments with smooth surfaces showing numerous thin leaves and scales of native silver on a large proportion of them.

Both the natural exposures and the artificial openings show that the agglomerate formation is divided into approximately rectangular blocks by two sets of dry vertical joints. Lines of fissure follow the courses of some of those joints and along those the mineralized veins occur. Their gangue consists of calcite. Sections of the veins are sometimes completely filled by metallic ores, especially smaltite or diarsenide of cobalt.

With the agglomerate and slate ash series, above described, are associated arkose or greywacke, quartzite and crystalline diabase. The slaty ash rock is not identical with true or argillaceous slate, but consists of the finer material derived from the modification by water of ashes and other volcanic materials, which became broken up and assorted when they came under the influence of the primeval sea. They are generally dark-coloured and obscurely banded parallel to the horizontal cleavage. In the country to the westward of the Cobalt district, along the Montreal river, around Lady Evelyn lake, &c., it is a common thing to see alternations of strata of considerable thickness, consisting of quartzites, arkose and this slate-like rock, which have evidently been separated by water from the volcanic materials that were being produced in abundance at that period of the earth's history and assorted into separate deposits of the coarser and finer materials.

The thickness of the agglomerate and slates, tuff or porphyrite probably varies considerably. At the Larose mine these rocks have a known depth of at least 295 feet,

Silver Nugget from the Larose Mine, Cobalt.

made up as follows: Upper half of the cliff above the mine, 25 feet of agglomerate; lower half of cliff, 25 feet of slates; slope from foot of cliff to collar of shaft, agglomerate about 40 feet; same rock to first level, 90 feet; from first level to bottom of sump, porphyrite tuff, 115 feet.

Along some of the joint-planes of either of the sets already mentioned as traversing the agglomerate, a disturbance accompanied by fissuring has occurred and these constitute the broken-up veins carrying the silver and other metals. It was observed that the stronger joints with slicken-sided walls often run in pairs close together, with a silver-bearing calcite vein in one or both of them. These joint-veins sometimes curve round through considerable angles up to 90° and they also give off branches. Examples of this may be seen at Little mine, from which a greater quantity of silver is said to have been extracted than from any other opening in the district. Some branching cracks, only about a quarter of an inch wide, filled with a fine red earth, run from one of the veins into the wall rock. This red earth was found to be very rich in silver, although no visible grains of the metal, or of any of its compounds, could be detected by washing it.

On the same vein which runs N. 23° W., a shaft has been sunk to a depth of 106 feet, from which a cross-cut has been made for 60 feet east and 70 feet west. The rocks cut by the shaft are blue agglomerate at the surface, followed by bright gray arkose, approaching quartzite, with an occasional rounded fragment of granite. Below this is the slaty rock which, on weathering, shows dull lines of stratification. Its colour is from dark bluish and greenish gray to nearly black.

Horizontal thrusts, dislocating the veins from two to ten feet, have occurred in some places. Examples of these may be seen at Little mine, Cobalt Hill mine and in the tunnel into the cliff just above the Larose mine.

A considerable portion of the eastern part of the Cobalt district is occupied by dark greenish-gray crystalline diabase in proximity to the agglomerate. In places this greenstone is probably intruded as dikes and masses in the agglomerate and its associated rocks; while in others it may occur as sills or overflows, lying in or upon these rocks.

Silver-bearing calcite veins, which also carry smaltite and resemble those in the agglomerate in some other respects, traverse the diabase at several localities in the district. Veins of this character occur on the following properties:—Violet or Handy, Welsh and Giles (north of the Foster mine), the Jacobs mine, the Hargraves, or McMillan, (south of the Jacobs). Diabase also occurs at the Watts or W. A. Allan mine. The Ben mine on the shores of Lake Timiskaming, now owned by Mr. Hotchkiss and associates, is in the agglomerate, but a greenstone rock occurs not far from it.

The majority of discoveries of silver, so far made in the Cobalt district, occur along lines running about northeast and southwest. But there is another set of veins crossing this course nearly at right angles. Two veins of this set traverse the property of the Larose Mining Company, the more northeasterly of which has been worked by running a tunnel along the vein into the cliff which rises a short distance to the south-eastward of the shaft. The other cross vein outcrops on the flat top of the hill at about 200 yards to the southwestward of the last. Here the earth has been removed so as to expose the glaciated surface of the agglomerate. In one part of the smoothed surface, the vein shows itself as a reticulated shining streak of polished silver and rock, three or four inches wide. A neighbouring part of this vein has been opened and a considerable quantity of rich ore removed.

The silver-bearing veins of the agglomerate throughout the district are themselves small, but since much of the ore is derived from the branch veins and the country rock adjoining them, they are more important than might be supposed at first sight. The gangue consists of calcite, derived from the agglomerate, with rarely a little quartz. The vein-matter is generally much split up, fractured, faulted and brecciated and many miniature horses are included. Branches are sent off, which often follow the secondary dislocations accompanying the main disturbance that caused the vein. Yet there is usually a continuity of productiveness along the general plane of fracture. On either side of this broken-up and interrupted plane the wall-rock on either side may contain much native silver in the form of plates, sheets and leaves, filling small fissures or gashes.

The values are mostly in the silver, all the other ores being worth comparatively little. From the information I could gather as to the output of the different mines, the total value of the silver produced in the district, from the time the first openings were made until the beginning of April of the present year, amounts to upwards of $1,500,000 and it may approach, but does not exceed, $2,000,000.

The following twelve metals have been found in the veins above described :—Silver, cobalt, nickel, copper, lead, arsenic, antimony, bismuth, iron, manganese, zinc and, lastly, gold in small quantity in one or two instances. Most of these metals have here entered into numerous combinations, among themselves and with sulphur and oxygen, to form a variety of somewhat uncommon mineral species.

The presence of such a number of different metals is a hopeful sign and one of the proofs that the containing rocks are essentially of igneous origin, notwithstanding the local modification of parts of them by water.

For convenience, I use the word "mine" in the same sense as do the prospectors of Cobalt, namely, to indicate any artificial opening in the rock, such as a shaft, an open cut, &c., instead of restricting it to its true meaning.

The silver and the ores of the other metals usually occur irregularly in bunches or scattered through the calcite and also through the country rock between the small veins of the groups, as well as for some distance inward from the walls. Most of the metallic silver is found in flat plates with extremely ragged and irregular edges, which, judging from a parcel of 150 or 200 pounds in the office of the Nipissing Mining Company, will weigh, on an average, from one-quarter to one-half pound each. In the open cut, called No. 26, on this company's property, I saw, at a depth of 30 feet, a vein of coarse crystallized calcite 4 inches wide, thickly studded with bright silver to the extent of fully 20 per cent of its weight. Only 4 feet in height as rich as this was exposed, but it passed into the rock below maintaining its width and value. A specimen of this vein weighing 130 pounds was taken to the Company's office. Specimens of pure silver, weighing from a few pounds up to twenty or more, have been obtained in a number of the mines and several pieces rich enough to be called "nuggets" have been found. A piece of rich ore, 5 inches thick and weighing 258 pounds, was found in the surface debris lying upon the outcrop of the Larose vein on the west side of the shaft. It originally formed a part of the full width of one "rib" of the vein and has a somewhat laminated structure, the layers being composed of smaltite, niccolite, native silver and calcite. This specimen was purchased for the Museum of the Geological Survey and, in order to ascertain the value of its silver content, five holes were bored through it. The drillings from these, on analyses, were found to contain about 18 per cent of silver. The high specific gravity of the smaltite and niccolite gave rise to a belief that this "nugget" might contain a larger percentage of silver. A mass of calcite and silver, said to weigh about 700 pounds, taken out of the Larose mine, was described as being so strongly held together by the silver as to require the use of cold chisels to cut it into pieces of convenient size to ship. "Nuggets" of mixed silver and calcite, weighing upwards of 100 pounds, are exhibited in the banks at Cobalt and in some of the mining companies' offices in the district.

As a striking example of the numbers of heavy pieces of native silver which may be picked out of the ore after it has passed through the crusher, I may mention that Mr. W. H. Linney, Superintendent for the Nipissing Mining Company, informed me that last year he had made a shipment to Mr. Ellis P. Earle, 31 Nassau street, New York, one of the partners in this company, of a petroleum cask containing 3,977 ounces of metallic silver and a large mass of niccolite with native silver protruding from it on all sides, and which was afterwards found to contain 780 ounces of this metal. The value of all, at 60 cents per ounce, was $2,854. At the offices of nearly all the mines in the district, the visitor is shown numbers of heavy pieces of native silver taken out of the respective mines.

The concentration of the silver in the metallic form near the present surface or at a moderate depth has no doubt been due to a chemical or electro-chemical process during a considerable period in former geological times, by which compounds of silver were reduced and deposited in their present form. It is not, therefore, to be expected that such heavy native silver will continue to any great depth. In the deepest parts of the Larose mine, 200 feet from the surface, a notable increase in the proportion of argentite has already taken place, dark red silver (pyrargyrite) has made its appearance and the changes due to surface influences in the wall rocks, gangue and ores, are less noticeable, as all these have assumed a firmer and fresher appearance.

The following notes on some of the individual mines of the Cobalt district are partly from personal examination and partly from descriptions given me by reliable persons, mostly the agents or the original owners of the properties. Up to the beginning of April, about forty different properties had been or were being worked. With three exceptions the depth attained was less than 100 feet, and in most cases it did not exceed 30 feet. At the Larose mine, the shaft (including sump) was 205 feet deep; at the Trethewey mine (J.B. 6) 100 feet, and at Little mine 106 feet. The company which has, so far, produced most silver is the Nipissing, which owns 900 acres of mining land to the southeast of Cobalt lake. Its mining operations have, as yet, been confined to one lot—R.L. 404—comprising only 10 per cent of the whole, but which includes the Cobalt Hill mine on its north side and Little mine in its southwest corner. Twenty-five other separate openings have been made on this lot, all in agglomerate rock. They have been numbered in the order in which work was commenced upon them, and more or less silver has been extracted from each. Only three of these openings exceed 30 feet in depth. According to the records in the books in the local office of the company, these workings have produced, since operations began in 1904, silver, with a small proportion of other metals, to the value of $1,045,000, of which about $145,000 worth is still in the storehouse at the mines.

From Little mine, a shipment of 20 tons was sent to market a year ago. It assayed 4,800 ounces per ton. At 60 cents per ounce this amounted to $57,600 and was the best car-load which has yet been exported from the Nipissing Company's mines.

At the working on the Company's property, called No. 19, there is an open cut 50 feet deep and about 200 feet long with a breadth of 6 or 7 feet. It is said that out of this cutting 200 tons of ore were taken, worth $1,200 a ton or a total of $240,000, which is more than has been produced by any other single opening in the district.

In the southeastern part of Lot R. L. 404, and close to the shore of Petersons lake, are situated the open cuts called Nos. 12, 13, 15 and 21, at two of which work was going on at the time of my visit. Very rich ore has been found in No. 12, and the superintendent stated that $25,000 worth of silver had been taken out of it ; also that some of the dressed ore of No. 13 assayed as high as 3,500 ounces per ton, and none less than 2,500 ounces.

Three car-loads of 30 tons each, or 90 tons in all, of cobalt and nickel ore were reported as having been sent last year from the Cobalt Hill mine. The Company received almost nothing for the nickel and arsenic contained in the ore. It was rather a singular fact that this ore contained less than half an ounce of silver to the ton. From the same mine, in 1904, the Nipissing Company's books show that 397,310 pounds of smaltite, containing only 5½ ounces of silver to the ton, were sent to New York. The heaviest single mass of cobalt ore found upon the Nipissing Company's land was in No. 8 open cut, which is about 100 feet long and runs about east and west, From this opening 132,000 pounds of cobalt ore, containing 10 per cent of the metal, were taken out. One large slab of solid smaltite was removed which was 16 inches in thickness and weighed over two tons. In this cutting, great quantities of cobalt bloom were uncovered along the south wall. The labourers threw it out in shovelfuls, in the form of a plastic mass.

The workings known as the Trethewey mines are situated on lots J.B. 7 and J.B. 6. Silver was discovered by Mr. W. G. Trethewey on both of these lots on the same day, 23rd May, 1904. The more northern lot, J.B. 7, which belongs to Mr. Trethewey personally, is called the New Ontario mine. The principal vein on this location is 8 inches wide and runs nearly east and west. A shaft was sunk upon it to a depth of 70 feet. On driving eastward at this depth, the vein soon forked. The drift was continued 40 feet on the northern and 190 feet on the southern division. This again split up into branch veins comprised in a breadth of 7 or 8 feet, between which the wall-rock was well charged with silver, and the small branches were also 'shot through' with the native metal. After much work had been done on the south fork, an experimental break was made into its southern wall and after crosscutting only four feet a larger vein than the one being worked was struck, which materially increased the output. A good deal of stopping was done on the small veins and adjoining rock, and prior to November, 1905, 44 tons of ore which had been taken from these workings had been sent to New York in two cars and sold for $110,000. Two other car loads of lower grade ore were also sent. Immediately adjacent to the veins, the wall-rock holds sheets or plates and nuggets of silver. One of the former had a superficies of about 25 square inches. Some small boulders of granite, about the size of a man's head, taken out of the agglomerate had been fractured *in situ* and were penetrated by veins or sheets of native silver. The gangue of all the veins here is calcite and, besides the native silver, it holds smaltite and niccolite.

Captain Reddington, in charge of these properties, informed me on the 13th of April, 1906, that since last November, two car loads of ore had been sent to New York, one consisting of 28 tons of rich material, which sold for $68,000. The second car carried about 30 tons, but he had not, at that date, received the return for it. These shipments, together with some ore on hand at the mine will, it is said, make a total yield, so far, of about $200,000.

On lot J. B. 6, immediately adjoining, to the south, the property last described, seven silver-bearing veins have been discovered, all of which run nearly east and west. On vein No. 1, where the initial discovery was made at the time the claim was staked, a shaft has been sunk to a depth of 100 feet at a point 200 feet southeast of the 70 feet shaft above described on J. B. 7. From the bottom of this shaft a drift has been run 60 feet east and 40 feet west following the vein. The latter consists of a group of stringers, all much broken up and mixed with the wall-rock. Sometimes there is a streak of vein-matter on one or both sides of this group. Native silver, in the form of bright leaves, occurs in the rock among the stringers, but most of the metal is found in the walls adjoining them. Open cuts have been made on the other six small veins and native silver has been found in all of them in the form of large disseminated grains, which sometimes occur in considerable bunches. The largest of these open cuts is 50 feet south of the above shaft and is 70 feet long by 30 feet deep. The country-rock at the openings on both J. B. 7 and J. B. 6 consists of a blue-gray, soft, fine-grained or amorphous tufa, which, towards the surface, holds rounded and angular fragments of volcanic ash-rock and of gray granite.

Among other openings visited in this part of the district, were the Timiskaming and Hudson Bay and the McKinley and Darragh mines. The last named has been already mentioned as the site of the first discovery of silver in the district. Only a small amount of work had been done on this property, but an opening which had been made on a vein at the water's edge in the southern angle of the lake, showed a promising amount of native silver, together with some smaltite.

At the Timiskaming and Hudson Bay Company's mine the silver-bearing vein which was worked runs northeasterly and is four inches wide, with silver also in the walls. I was informed that here a stope, only 30 feet long and 25 feet high, had yielded two car loads of ore, which sold in New York for $32,500 and $7,000 respectively.

The Jacobs mine, already mentioned, lying to the southeast of Petersons lake, affords one of the best examples of a silver bearing vein cutting the dark greenish-gray crystalline diabase of the district. The vein, which is of calcite, runs north and may be seen along the west side of an adit which has been driven 120 feet on its course into the side of a hill. At first the vein is only two or three inches wide, but in advancing into the adit it is seen to increase to four and eight inches, and in one part, where it is split up and brecciated, it has a width of ten inches and holds bunches of native silver. In another part also the vein was observed to be rich in the metal. Higher up the hill, an open cut has been made along the same vein with a depth of 25 feet, for a distance of 70 feet, from which it is continued on the adjoining White-Hargraves property. Smaltite and a mineral like niccolite also occur along this vein.

The captain in charge informed me that 23 tons of ore, containing about 3,000 ounces of silver to the ton, besides a little cobalt, nickel and arsenic, had been shipped from the mine during the present spring; also that last year two car loads of ore had been sent from this vein and three from another one, which had been previously opened on the property.

Mr. Henry Richardson, manager of the McLeod and Glendenning (or Hanson) mine, informed me that two calcite veins occur on that property, 300 feet apart, both running northeast and southwest. The one to the northwest is in diabase and is rich in silver, with smaltite; while the other is in slaty agglomerate and carries no silver. The widest part of the productive vein is four inches. The mine consists of an open cut 60 feet long. Ten tons of ore have been shipped.

Mr. Richardson also informed me that the Violet mine, on the lot adjoining the Hanson to the north, is entirely in diabase. Some of the rock is here rather coarsely crystalline, while some of it is fine-grained and as darkly coloured as that of the Jacobs mine. The Violet mine has a shaft 90 feet deep and a cross-cut level has been started to the southward. A little silver ore has been taken out of an open cut. Both the Hanson and the Violet mines show a good deal of smaltite.

The Drummond mine is at the east end of Kerr lake. Here two smaltite veins occur about 8 feet apart. Between these, horizontal streaks of silver are found in the agglomerate which constitutes the country rock. There is an open cut about 20 feet deep and a shaft is being sunk.

The northern angle of the Lumsden and Booth, or Gillies, timber berth protrudes from the south into the centre of the silver district. This has not been disposed of by Government for mining purposes and it has not been referred to in the above descriptions of silver-bearing properties, although some rich veins are known to occur in it.

The number of veins or vertical zones of fracture carrying silver, which have been already found in so limited an area as the Cobalt silver district, must be considered large, and the question is asked—what are the prospects for further discoveries within the district in the future? Where so many discoveries have been made, while so large a proportion of the surface of the rock is covered with earth and this again by a thick growth of coniferous trees and deep moss, it is reasonable to expect that many more will follow when the timber is removed and extensive costeaning is undertaken.

The Nipissing Company is installing heavy machinery for the purpose of pumping water from Petersons lake to high levels, with a view to washing the earth entirely off the surface by the hydraulic process. This will allow of a complete search being made for the outcrops of the vertical silver-bearing zones, which are often inconspicuous at the surface and might escape discovery by the ordinary methods of prospecting.

From our present knowledge it would appear that the silver has a regional environment as well as certain local geological relations, resembling the mode of distribution of the richer nickel ores in the Sudbury district. There, outside of a certain area, although the geological conditions may be similar, no one ore rich enough to work can be found. Similar phenomena obtain in other parts of the world in regard to other metals, such as tin and mercury. Although diligent prospecting has been carried on throughout a large area outside of the silver district immediately around Cobalt, no discoveries of similar occurrences of silver have been made. I may, however, mention that traces of native silver have been discovered recently on the east side of Lake Timiskaming at a place which lies in a line with the northeasterly course followed by the successive silver mines in the centre of the Cobalt district. This discovery is close to the Wright silver-lead mine, which is in a very pronounced volcanic agglomerate. A thorough exploration of this part of the lake shore and the country behind it might bring out interesting results.

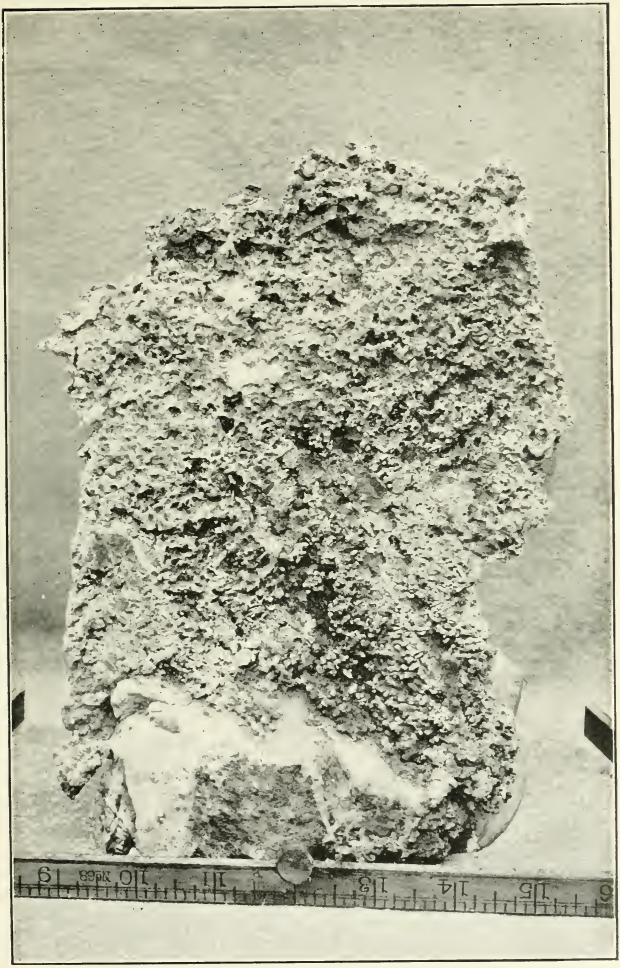
Small quantities of smaltite have, however, been found in different localities beyond the silver district. It now appears that the silver is not necessarily connected with this mineral. It has been mentioned on a previous page that in the Cobalt district the largest bodies of smaltite so far tested contain only traces of silver. Unless the conditions necessary for the production of the silver itself are repeated in some other locality no further important discoveries of this metal may be made in this part of Canada.

One of the most vital questions in connexion with the silver mining in the Cobalt district is that respecting the depth to which the deposits may continue. The direct evidence afforded by the main vein of the Larose mine carries us down only 205 feet from the collar of the shaft, but the silver-bearing character of two other veins, which cut the 80 feet of agglomerate, &c., above the level of the collar, may be considered in this connexion, which would give us a depth of nearly 300 feet. The ore and rock brought up from the lowest workings of this mine show that the vein has undergone no material change so far, being about equally rich and varied in its contents all the way down ; but, as above mentioned, there is in the lowest workings an increase in the proportion of argentite, and the vein and its walls have a firmer and fresher character. Good sized flattened nuggets continue to be found among the native silver. At the 800 feet level the line of fracture is marked by two parallel calcite veins of 5 and 7 inches respectively, separated by an interval of slaty tufa, rich in native silver, which also extends, as thin plates, into the wall-rock on either side, as far as four feet in some parts.

It may be reasonably supposed that the farther a vein can be traced on the surface, the deeper it is likely to go. Although nearly all the individual veins are small, they may be regarded as only one manifestation of a mineralized plane or zone of fissure or disturbance. The fact that these fissure-planes, or lines of fracture, are vertical, and that they coincide with the prevailing system of strong joint-planes are circumstances favourable to persistence in depth. The agglomerate and its associated rocks have been found, by means of the shaft and boring at the Larose mine, added to the height of the rocks above the shaft, to have a depth of at least 300 feet, but it may be much greater than this. The thickness of the jointed agglomerate may be found to have some influence, not only on the depth of the fissures, but also on their argentiferous character, as the silver appears to have been derived from the country-rock in which the veins occur. If the veins prove to pass down through the agglomerate into some underlying rock their silver contents may continue downwards with them.

If a comparison be made between the geological and mineralogical conditions at Cobalt, and those of the Thunder Bay silver region, it will be found that there are more points of difference than of resemblance in regard to the principal group of mines in the latter region, which embraces the Rabbit Mountain, Silver Mountain, Porcupine, Beaver and West End mines. In all these the silver occurs, both native and as argentite, in well-marked brecciated veins of quartz, which cut down through a heavy sheet of diorite into a great thickness of darkly coloured unaltered shales, lying horizontally. These belong to the Animikie series, which is much newer than the rocks of the Cobalt district. The conditions at the Shuniah and Thunder Bay mines a short distance northeast of Port Arthur, have some resemblance to those of the mines just mentioned, and both of them were rich in native silver at the surface, but on sinking, it soon gave out. At the Silver Islet mine the conditions were quite different. A broad dike of a peculiar variety of diorite, which can be traced for miles parallel to the northwest shore of Lake Superior, cuts through a great thickness of nearly horizontal gray and nearly black unaltered shales. A very strong vertical calcite vein cuts this dike almost at right angles. Except where traversing the dike, the vein holds nothing but a little galena. But the part which lay within the dike, and constituted a perpendicular square prism, proved to be rich in argentite and native silver, to a depth of about 1,000 feet, when it began to fail and at 1,200 feet it had become so poor as to be no longer worth working. The total value of the silver taken from this mine amounted to about $3,250,000. The rock of the dike itself, on analysis, was found to contain a variety of metals in notable quantities.

On the shore of Thunder bay, a short distance to the northeast of the Shuniah and Thunder Bay mines, a rather small vein which cuts both the Huronian and Animikie rocks was worked to a limited extent under the name of the 3A. mine. It was noted for producing occasional specimens of nickelite.



Silver Nugget from the Larose Mine, Cobalt.

Geology of Parts of the Counties of Labelle and Wright, Quebec.

Professor Ernest Haycock.

Pursuant to instructions from the Acting Director, I left Ottawa on June 17, to continue mapping the rocks of the 'Lièvre River and Templeton Phosphate District.' I was accompanied for the season by Ralph K. Strong, B.A., who proved a most efficient and valuable assistant.

The map of the district includes all the township of Portland, the northern half of Templeton, and the northwestern third of Buckingham. Small portions of the townships of Hull, Wakefield, Denholm, Bowman, Villeneuve and Derry also lie within its borders. The area measures approximately fourteen miles east and west, and eighteen miles north and south, or about 250 square miles.

Work was begun around the northern arm of Wakefield, or Big Blanche lake, and an effort was made to trace to their disappearance, or to the limits of the map, the limestones and gneisses which here trend northerly. Finding the rocks traceable, this method was continued, and the country to the east of the Lièvre was thoroughly examined, the distribution of the more conspicuous belts being ascertained. The remainder of the season was mainly spent in examining the township of Buckingham. On the close of field work, Sept. 26th, I returned to Ottawa.

Throughout the area thus examined the rocks found were in general similar to those described in the Summary Report for 1904, pp. 233-238. Some important variations in texture, mineralogical, and chemical composition were observed, which, with the surface distribution, have a bearing upon questions of origin. These will be briefly referred to as each group is taken up, but no extended discussion of group relations or theoretical questions will be undertaken here. With a view to giving this report a practical character, the groups will be designated by their predominant economic or mineral characteristics where possible, or by the numbers under which they are described in the report cited.

Part I.—Western Part of the Northern Sheet.

Asbestus-bearing Rocks, mainly Crystalline Limestones.

These rocks occupy a relatively large area in the northwestern part of the district. In a narrow band they enter the district just south of St. Pierre de Wakefield, in the little valley of Pelissier creek, lot 28, range xiii, Templeton. The brook flows along the northwest contact with gneiss and intrusives, and limestone can be seen at intervals for a few rods up the slopes to the southeast. It is rich in secondary graphitic minerals, and passes into serpentine and pyroxenite along the contact laid bare by the brook. Asbestus occurs in this contact zone in thin sheets or rudely concentric layers, exactly as described by Dr. Ells for typical occurrences about Perkins Mills*. Some develop-

* Annual Report, 1899, vol. xii, pp. 105-106.

ment work was being done here in June with a view to testing the deposits for paying quantities of the fibre, or of less pure asbestus rock. The limestone here trends northeasterly, but disappears beneath sandy deposits. Half a mile north on lot 26 range iv, Wakefield, it appears again, graphitic, with pyritous sandy layers, rusty-weathering, in good exposures on the hill slopes a little west of the post road. It disappears again in swamps and wooded country, and reappears nearly a mile to the northeast, on the northern part of lot 29, range iv, Wakefield, though the low land between, and occasional limestone boulders in the soil, leave no doubt of its actual continuity.

From this point there are practically continuous exposures, over a belt of country from one to two miles wide, for about four miles, to near the northeast end of Wakefield lake. The surface is moderately level, generally cultivated, or occupied by the various extensions of the lake. Siliceous bands and intrusives are not uncommon, but the predominating rock is limestone. Asbestus has been reported in small quantities from various localities in this area, and is liable to occur wherever the conditions have been favourable, as at contacts with the gneiss or intrusive masses. On the northern parts of lots 28, 29, 30, range IV, Portland west, the belt abruptly terminates or is cut off squarely by hills of gneiss. No direct continuation in this direction, even in diminished volume, could be found.

Westwardly, the banded gneisses, trending northeasterly, are crossed for about half a mile from the lake, when the limestone is met with reaching beyond the borders of the map and comparable in width with the belt to the east of the lake. It extends north and east, but is cut off abruptly to the south by well bedded gneiss. The juncture is broken and irregular, and suggests fault displacement.

Followed northerly, this belt shows the same characteristics as the lake belt; the limestone is graphitic; asbestus is common along the contacts; and thick interbedded sheets of quartzite, garnetiferous gneiss, or more sandy pyritous and rusty-weathering gneiss, occur, but are generally too much broken and concealed to permit of continuous tracing; for this belt is rather easily weathered, soils and surface deposits are deeper, and exposures much less frequent and continuous than in the rugged and hilly country underlaid by the more resistant gneisses and intrusives. Showing these dominant characteristics this belt of rocks widens out beyond the western margin of the sheet, apparently bounded by a range of abrupt hills not more than one or two miles away. It reaches the northwest corner of the map and then sweeps southeast and east, sending a tongue north over the boundary to Escalier lake, and then sweeps south and southeast.

Near Hollands Mills post office the belt is quite narrow, certainly less than half a mile in width, but it widens to about three quarters of a mile and holds this width nearly to McFee lake on the southern margin of the map. North of this lake it is cut up by the intrusives and nearly disappears. The remnants bend eastwardly, but are not again seen on the west side of the Liévre. A sharp valley one quarter of a mile wide leads out to the river flats between rugged bluffs of coarsely crystalline rocks. It is occupied by Ryans creek, and the bottom is filled with deposits of clay. The limestone band may pass through this gorge and reach the river. The existence of the valley favours this view, but no direct evidence was obtained.

This belt of rocks, of fairly constant composition and structural characteristics, was traced continuously for about twenty miles, and with slight breaks, some five miles farther. They form an ox-bow area very much widened out at the bend.

North of Wakefield lake, and south of Hollands mills, asbestus is found in small quantities. Dark coloured, pyroxenic masses occur about Poltimore, very irregular in outline and probably intrusive in the limestone. They yield rather dark-coloured mica. One of these deposits on lot 48, A. Denholm, was being opened up, but no others were being operated in July.

Hornblende Gneiss.

As No. 7 of the important rock types met with last season, a coarsely crystalline rock, composed mainly of a gray feldspar and abundant hornblende, was described as occurring east of Wakefield lake and extending beyond the northern boundary of the southern sheet. A similar rock was noted south of McFee lake.

Its continuation northward was taken up this season, and though not continuously traced, it was occasionally found lying immediately east of the west arm of limestone. The country is rugged and quite densely wooded and the dominant rock is not easily determined.

South of Hollands Mills P.O., a low ridge runs along lot 14, VII, with good exposures for its whole length of nearly half a mile. Its eastern slope is of limestone, with rusty gneiss and pegmatite inclusions. It dips east at a high angle. Well banded quartzite and gray gneiss, a few feet in thickness, lie next the limestone, and just beneath is a belt of granitoid gneiss fairly uniform in texture and composition. The foliation is parallel with the bedding of the quartzite and limestone and there is a tendency to massive bedding parallel with that of the supposed metamorphosed sedimentary rocks. It appears to be composed mainly of a gray to reddish orthoclase, black hornblende, and a very little quartz. Similar rock crops out west of the post road on 16 and 15, VII, and trends south just to the west of the limestone. East of McLeod lake more free quartz was noted and the composition approaches that of hornblende granite. It was then traced southwards, with continuous exposures in burned country, without a break, and found to connect with the previously known area south of McFee lake, which bends around east and northeast to Dodge lake. Passing southwards, the feldspars lose their reddish tints, hornblende is more abundant, foliation more general, and the rocks become dark gray in colour and less like granite in texture.

From the continuity of these rocks on the east, and their known occurrence on the west, it seems almost certain that a similar continuity must exist there, escaping detection on account of the slight changes in mineralogical composition, and the difficulty in determining the dominant rock where the surface is thickly wooded. The fault displacement that disconnects the limestone belt would also break up the continuity of the granitoid gneiss. A corresponding displacement occurs on the eastern side, apparently less in amount than on the west, but pushing the limestones to the east of Lake Terror when the previous trend would have carried them west of that lake. The sharp break previously mentioned as occupied by Ryans creek is in line with this line of displacement.

These rocks thus form a roughly concentric belt within the bow-shaped belt of limestones, and follow closely its inner edge.

Their appearance last year, when this singular distribution was not known, was thought to be more consistent with an igneous origin, even though a heavy bedding was discernible. The additional facts confirm the view that they were originally sedimentary or, at least, bedded rocks without pronounced differences of composition in contiguous beds, lying above, or perhaps below, the limestones and subsequently folded in with them. Their thickness is not great, probably averaging a few hundred feet. They are generally barren as regards economic minerals.

The Banded Gneiss, or the Mica-and-Apatite rocks.

Under this heading are included No's. 1, 2 and 3 of last year's report. They are banded or bedded rocks, hornblendic, garnetiferous, or quartzose, regarded as of sedimentary origin, differences in composition being ascribed to the varying character of the accumulating sediments. Although the general trend of these rocks in the south is northeasterly, an extension northerly and northwesterly with interbedded sheets of limestone was traced along Grand and McArthur lakes. These were, this season, traced several miles farther north, crossing ranges III., IV., V. and VI., in Portland west. The bedding is well defined and rather free from twisting and contortion. The strike is approximately north and south with high dips to the east. Garnetiferous gneiss is common. The limestone bands of the lakes are somewhat centrally located. They disappear a short distance north of McArthur lake.

Numerous trial pits and old workings for mica and phosphate are found in this area. None are now being worked but they are said to be by no means exhausted. All the deeper workings being filled with water were inaccessible to observation, but superficial appearances favoured this view.

Phosphate rocks of the Lièvre river.

Elevated rough and hilly country shuts in the limestone area first described. The river swings southwesterly across the strike in the southern part of the sheet. A sharp break occurs in these hills where Priest creek enters from the northwest ; a broader hollow runs north to Escalier lake, occupied by a tongue of limestone ; and quite a broad gap occurs on the east opposite Notre Dame de La Salette. No limestone was found passing through the gap opposite La Salette.

This area was not given as thorough an examination as those previously described. It was studied by E. D. Ingall and others while the mines were in operation and the facilities for observation much better than at present.

Enough was seen of these rocks, however, to lead to the conclusion that they belong to the banded gneisses, with considerable volumes of various intrusives. Some of these are massive and granitic in character, as at High falls, where a massive band of these rocks parallel in trend with the gneiss crosses the river in a northeasterly direction, giving rise to these beautiful falls.

The prevailing strike is parallel to the contact with the limestones of the large area already described, and the belt is thought to be closely related to, if not a part of, the same series.

Only two bands of limestone were seen within this river belt. One comes from the northeast on the west side of the river and continues southwesterly and occupies the north side of Barbut lake. It is nearly a half mile wide at the north end of the lake, but is barely to be found at the south end. In this diminished volume it was traced to Central lake, but was not found beyond. The second band lies about a quarter of a mile east of the other, in the bend above the first rapids. It is only a few rods wide, and runs parallel with the first band and the accompanying gneiss, or northeast and southwest. It was traced about half a mile to the southwest, but was not seen beyond.

It may be mentioned that a well marked longitudinal valley runs the whole length of this loftier northern part of the river belt to its termination at the gap opposite La Salette, and it was confidently expected that the limestone band of Barbut lake would be found at intervals along this hollow. Though it was not found south of Central lake, it was not proved to be absent, and may with diminished and irregular widths occur at intervals, and form a softer band which by more rapid weathering has given rise to a valley. Quartzite and garnetiferous gneiss were noted bordering a swampy tract at its southern extremity. Mr. J. F. E. Johnston noted small outcrops of limestone on the road running south on the west side of the river from Chalefoux's landing towards Priest creek (Sum. Rept. 1904 p. 245), which would correspond in position with the continuation of this band.

As previously indicated, none of the phosphate mines are now working. The roads are becoming choked with undergrowth, old mine buildings are tumbling down, yawning pits partly filled with stagnant water confront one in the bush, and a general air of desolation prevails. A few tons of apatite are, however, taken out yearly by individual workmen, who claim that by working over the richer parts of the old dumps, or by taking out small richer pockets of the ore, the work pays at the present prices, where, with larger gangs, poorer rock would have to be worked and it would be impossible to make wages. This erratic method of working must be relatively expensive, and its paying in a small way raised the question whether there was not a gleam of hope for the future of this abandoned and agriculturally worthless section.

The foregoing discussion sets forth the more outstanding features of the country rocks and the dominant character of the surface of the northern part of the district between its western boundary and the Lièvre. Contortions and twistings are frequent and often confusing, but the prevailing strikes can in general be made out corresponding well, as would naturally be expected, with the surface trend of the belts. The dips are almost invariably high, less than 45° being very exceptional, while from 60° to 90° is the rule. The prevailing direction is to the east, the limestones on both sides of the ox-bow belt described dipping beneath the bedded gneisses. The strike of the gneisses of the hills about Mud lake, north of the limestones, in Bowman, is east and west, vertical or north dipping, but no contacts were seen there and the relation is not known positively. In spite of the broken and minor irregularities of distribution, when the outcrops are coloured upon the map now in preparation, as they were while on the ground, and when nearly the whole area can be swept by the eye, as it can be from the hills about High Rock, minor irregularities are merged, or lost sight of, in the more general features and it seems easy to see a definite distribution which is susceptible to structural explanations.

It is assumed here that these rocks are the metamorphosed representatives of once stratified sedimentary series, conformable or with no great unconformabilities. Then the following explanations may be offered with a considerable degree of probability. That the series have been crushed into a closed or isoclinal fold and overturned slightly. That it is either anticlinal with an axis plunging north, or synclinal with an axis plunging south. If the former, the garnetiferous gneiss and axially lying limestones of Grand and McArthur lakes are the underlying and oldest portions; if the latter, then the apatite-bearing-belt along the Lièvre becomes the oldest, and the limestones of those lakes the uppermost members. The occasional synclinal tendencies of the lake limestones rather favours the latter view. The interpretation has a bearing upon the age of the rocks in the area to the south, in general trending northeast and southwest, and which these widen out and join.

The intrusives of this area are both varied and numerous, but of types discussed somewhat in the report of the previous season. There are no bodies sufficiently extensive to require special mention here. Pyroxenic rocks are of frequent occurrence. The lighter coloured usually lie near the limestone bands, or in their continuation, and some additional facts bearing upon their origin were noted.

Eastern part of the Southern Area.

In connexion with No. 9 of the rock types mentioned in last season's report it was stated that a boss of coarsely crystalline basic rock lay east of Grand lake, and was traced northeasterly as far as Newton lake. Its continuation was found on the northwest side of Newton lake and on both sides of Farley creek. It is coarse and even porphyritic in places, generally lighter in colour and more acid in composition than the portions seen last year.

It passes beneath the clay of the river banks, but has not been looked for east of the river.

Mica and Phosphate belt of Banded Gneisses.

At the outlet to Newton lake and along the portage to the Lièvre a thin band of limestone is exposed at intervals, interbedded with banded gneiss. This band was traced almost continuously from McGregor lake. It marks the northern border of the mica and apatite bearing belt of banded gneiss and intrusives which was described in last season's report. This belt is cut at right angles by the Lièvre river, and is about six miles wide.

Apart from local twistings the strike is north 40° to 50° east vertical, or with high dips. Quartzites are abundant, often weathering rusty from contained pyrites. Limestone bands are thin and infrequent. One was traced from Maskinonge lake for two and a half miles to its disappearance beneath the clay of the river, and was found again at Trout lake one and a half miles to the northeast. There are traces of two or three other broken bands, but their volume is relatively very small.

A large mass of granite occurs about Davis lake, lots 12 and 13, range I, Portland east. Portions are without foliation. The rock is made up of feldspar, hornblende, a little biotite and considerable free quartz. The texture is that of normal granite. The texture, however, is finer near the banded rocks, and they are much broken and fused near the granite. The composition is much the same as the rock described as No. 6 in the Report for 1904, which occurs in the hills north of McGregor lake, and about Dam lake, though the massive character is much more pronounced at Davis lake. It is not unlikely that they are superficially separated portions of the same rock magma.

Mica occurs abundantly throughout this belt and apatite is often associated with it.

Two new openings had been made in the district since last season, one east of Sucker lake on lot 7, Gore of Templeton, and another north of Plumbago lake in lot 2, range X, of Templeton. Some good mica had been taken out, but work was not going on when they were visited. At the excellent prospect opened up last season, just east of Dam lake in the Gore, work was reported as held up on account of legal disputes. The quantity taken out was not ascertained.

The following information was furnished respecting the work done by the Wallingford companies. 'The Wallingford Bros. Ltd. have opened up the property, east ½ of lot 1, range I, Portland east, partly developed by Mr. Poupore in 1893 and again worked in 1900, and have done a considerable amount of prospecting, developing several leads of fine mica. The same company also did a good deal of work at the Denholm mine. The Wallingford Mica and Mining Co. have extensively developed both at old Wallingford mine near Perkins Mills, and the Battle Lake property. The merchantable mica shipped totals up 40,000 lbs. besides about 200 tons of phosphate which was taken out in the course of mining the mica.'

The Blackburn mine was not visited nor was any information obtained as to the recent progress of the work there.

Graphite belt of banded gray gneiss with numerous limestone bands.

The mica bearing rocks pass southeasterly into grayer, less quartzose, more pyritous and calcareous, bedded rocks, parallel in trend and structurally similar to the mica belt. Mica and apatite, are, as a rule, absent, but graphite is of frequent occurrence, and several deposits of graphitic gneiss occur.

This belt of rocks occupies the remainder of the district, being at least five miles wide. It joins the mica belt on the east side of Plumbago lake, and runs northerly a little to the east of the Templeton and Buckingham township line. On range VIII of Buckingham it bends to the northeast, crossing range IX and reaching the Lièvre about the middle of range X. The trend of the rocks to the southeast is roughly parallel with this line. They run north for two or three miles and then bend around to the northeast, continuing to and beyond the area visited.

The volume of limestone is considerable. It appears to be interbedded with the gneiss, and is pretty widely distributed, being found in nearly all the larger outcrops, except where the volume of certain rocks regarded as instrusives is large. It is thus found, almost continuously, from the western extremity of Donaldsons lake eastwards in ranges V and VI, and from lot 17 eastward in ranges VII and VIII.

Two areas of the interbedded gneiss and limestone, separated by intervening masses considered as intrusives, were traced north and east from the vicinity of Donaldsons lake. On the eastern band are the workings of the old Walker property lot 19, VIII, and on the western near Donaldsons lake are two other graphite properties. The immediate vicinity of each of these workings has been mapped by J. White and A. A. Cole and the results of a study of the occurrence of the graphite, by the latter, are given in the report of the Mines Section of the Survey for 1897 (Report S. pp. 66-73.)

The rocks separating these areas from each other and from the broader river area are of a wholly different character. They appear to be a quartz-free admixture of gray and red feldspar and black hornblende, often very coarse, as on lots 19 and 20, range VII. In the extension of this mass northwards and in the bordering zones they become finer in texture and more banded, as though intimately injected between the layers of the banded gneiss but cutting across them freely. This band forms the rough and hilly country bordering the river flats on the west in ranges VII, VIII, and IX. It reaches and crosses the river on the southern part of range X, but in diminished volume. Southerly the rock does not reach the road on range VI.

The second mass was met with between McLean and Devine lakes. It runs southwesterly to the concession line between VII. and VIII., lots 23 and 24, and was traced southerly to range VI. It does not reach Donaldson lake in any notable volume. On the post road, a mile and a half northeast of McLean lake it was not identified as a separate mass.

These rocks in themselves appear entirely barren of any minerals of economic value, but if the interpretation offered as to their intrusive relations with the graphite-bearing rocks is correct, they may have a very close connexion with, and relation to, the graphite deposits in the immediately adjacent calcareous bands.

In the graphite industry no new mines have been opened since A. A. Cole's report, previously cited, was written. At Donaldson lake preparations were being made for resuming work on the property on lot 28, range VI. Nothing was being done on the adjacent property, lot 26, and the buildings appeared to be getting out of repair. At the old Walker mine, lot 19, range VII., the mill was being put in good repair, new machinery was being installed, and there was every outward indication that this property would soon become an active producer.

St. Bruno Mountain.

Dr. J. A. Dresser.

Four weeks of the last season were spent in the examination of some parts of the counties of Wolfe, Arthabaska, Drummond and Megantic; this examination was necessary for the completion of the mapping of the copper-bearing rocks of the Eastern Townships. The boundaries of these rocks were traced through portions of these counties, and several occurrences of copper were examined. Amongst these a prospect of some promise occurs on the farm of Georges Lemieux, in range VIII., lot 1, Wolfestown. The ore is chalcopyrite and occurs in several stringers in three feet of dolomite, near the contact with a basic volcanic. In lots 5 and 6, range V, Chester tp., Arthabaska co., an open cutting fifty feet long has been made in a rock bearing chloritoid, similar to that which occurs at Harvey Hill, in Leeds tp. A mass of quartz three feet wide, and conforming to the foliation, carries bands of chalcocite, some parts of which are five inches wide. The work has been done by Mr. Stevens of Windsor Mills, Que.

On the sixth lots of ranges II. and III. of the same township a small amount of chalcopyrite two inches wide by two feet long, was visible for a time. A cutting of less than two feet into the rock removed all the ore as far as could be seen at the time of my visit. I am credibly informed that this property has been sold for $12,000, $3,000 of which has been paid in cash to parties in the state of Connecticut, and that a joint stock company capitalized at $500,000, has there been formed to acquire and operate the property. This occurrence, like many other copper stringers throughout this belt, is of no economic importance.

The remainder of the season was occupied in petrographic examination of St. Bruno mountain, or Montarville, one of the Monteregian hills. The examination of this series of remarkable volcanic hills was begun some years ago, but has been suspended for the past three years. The hills are eight in number, of which four have been petrographically examined in recent years, viz.: Mount Johnson, by Dr. F. D. Adams, as a private research, and Yamaska, by Dr. G. A. Young, and Brome and Shefford mountains by the present writer, for the Geological Survey. St. Bruno, the examination of which is now about finished, will thus be the fifth of these hills to be completed. Besides these, two others are already in course of examination, so that the investigation of the series should soon be completed.

St. Bruno mountain is the first of the Monteregian hills east of Mount Royal, and is fourteen miles from Montreal, in the county of Chambly. It occupies rather less than three square miles. Rising from the St. Lawrence plain, which here has an elevation of 100 feet above sea-level, this hill gradually attains an elevation of 560 feet at the northern side, two miles distant. The northern side presents a steep, cliff-like face more than 300 feet in height. This type of profile, an abrupt face on the north with a gentle slope towards the south, is characteristic of the Monteregian hills. Its cause is a physiographic question yet to be solved.

The sedimentary rocks around St. Bruno have long been regarded as belonging to the Lorraine formation, but in order that a detailed examination of their fossil contents might be made, a collection of fossiliferous rocks was obtained from various points. The specimens now await determination in the palæontological department of the Survey. In making this collection, as well as in several other parts of the season's work, I was very efficiently aided by Mr. Robert Harvie, jr., student in Applied Science at McGill University.

St. Bruno mountain is composed of an intrusive mass of igneous rock, surrounded by a rim of hornstone, which has been formed by the alteration of the sediments adjacent to the intrusive. The igneous rock has the general character of essexite, an seems to have been wholly formed at one period of intrusion. In one part, less than an acre in extent, the rock becomes a light-coloured syenite, and in other portions it becomes very basic, containing large amounts of pyroxene and olivine. A suite of specimens for thin sections has been collected and will be studied in detail later. Specimens for chemical analysis are also in the hands of Mr. Connor, of the chemical staff of the Geological Survey.

Sheets of the igneous rocks frequently penetrate the hornstone rim near the base of the mountain, and dikes are common in the hornstone and less altered sediments, but are rarely, though sometimes, found in the igneous rocks. Some of these apophyses furnish interesting studies in rock differentiation.

The topography of the mountain is such as to give it an imperfect drainage. Its surface is very uneven. The coarse-textured parts seem to disintegrate more rapidly, and thus basins are formed which give rise to numerous small lakes. The largest of these are known locally as Lac Seigneurial, Lac à Daisy, Rond Eau, Lac des Atocas, and Lac des Ormnes. Most of these are drainage lakes, apparently, but two of the larger, Lacs Seigneurial and Rond Eau, give evidences that they are in part fed by springs. The present relief of the mountain is wholly due to the removal of the surrounding sediments by erosion and denudation, and to the better resistance to these agencies by the igneous and altered rocks, chiefly by the hornstone rim. It is thus a residual hill of the butte type.

The strata surrounding this mountain are nearly horizontal and would indicate that as far as the present surface is concerned the igneous mass is a filled neck, but whether the neck ever reached the earlier surface as a volcanic vent, or merely led to a larger subterranean body, or laccolite, above, it is not easy to determine from present evidences. Remnants of hornstone are so numerous on even the highest part of the mountain, that the conclusion is difficult to avoid that they once completely covered it. On the whole, perhaps, the most probable view is that the syenite area, northeast of Lac à Daisy, represents the actual pipe of a volcano, while the remaining part of the mountain has been formed by laccolithic off-shoots, and outward magmatic stoping.

Rougemont, one of the Monteregian hills, stands between Beloeil and Yamaska. It is in the county of Rouville and has an area of some six square miles, with a height of about 1,400 feet. The igneous rocks, which are intrusive through the sediments, are all phases of essexite, as far as yet known, except some dikes and irregular masses on the summit, which are fine textured, and evidently contain large proportions of iron.

On the Whitfield farm at the south side of the mountain, the strata dip away from the igneous rock at an angle of 10 degrees, but at about 300 feet from the contact they seem to suffer a sharp anticlinal fold, and dip towards the mountain at a higher angle than they before maintained towards it. In the brief examination of the locality, which was made only for comparison with St. Bruno, it was not learned whether this structure is general around this mountain, or not.

The Valley of the Tobique River, N.B.

Professor W. A. Parks.

Acting on instructions received from the Director of the Geological Survey to examine a portion of northern New Brunswick, I proceeded to St. Stephen, N.B., for outfitting purposes and thence to Plaster Rock, where I was fortunate in procuring, without any delay, the services of two good men.

The operations of the party were confined to the region adjoining the forks of the Tobique river in Victoria county. A section of country stretching northeast for about thirty miles, with an average width of ten miles, was examined as carefully as time would permit. Owing to the unprecedented lowness of the water in the Tobique river, travel by canoe was quite impossible, so that access to the different parts of the region could be gained by overland expeditions only. The topography of the region has been well determined by previous investigators, but some additional information was obtained concerning the course of certain streams. Track surveys were also made of several bush roads in the eastern part of the area.

The whole region is very rough, with numerous well-defined hills showing a relief of 1,500 to 2,000 feet. All the important elevations were ascended, and numerous barometric readings were obtained. From these results, and from sketches obtained from the hill tops, data are available for the construction of a contour map of the area.

The rough character of the section makes it unsuitable for agriculture; this is particularly true of the region south of the Tobique river. At various points along the river sufficient alluvial deposits have accumulated to make farming not only possible but lucrative. North of the Tobique, and along the valley of the Mamozekel, excellent clay loam overlies the rolling Silurian rocks and will doubtless prove a profitable field for the agriculturist. The timber is very diversified in character, presenting a mixture of hard wood with coniferous trees; among the former are maple, beech and elm, as well as the semi-hardwood, birch. The coniferous trees are represented by white and red pine, spruce and balsam. The writer, familiar with northern Ontario, was impressed by the profusion of yellow birch and the total absence of the Banksian or pitch pine. Practically all the pine has long since been harvested from the area, but much excellent spruce, yellow birch, elm, maple and beech still remain. Forest fires, particularly the so-called Tobique fire of about forty years ago, have devastated large sections of the area examined.

Geology.—The geology of the region is very interesting, but somewhat difficult, as is shown by the diversity of opinion expressed by different authors. The present writer hesitates to express an opinion as, in his judgment, the question rests with the microscope for its solution. Pending the examination of rock sections, it may be stated that the following series of rocks are found within the narrow area examined.

I.—Various Archæan crystalline schists and eruptive granites. These rocks are exposed on the Serpentine river near the mouth of Boover brook and in the region to the southeast.

II.—Fine fissile slates with graphitic markings and possibly the remains of organisms. These rocks are probably referable to the Cambrian and are best exposed on the Serpentine to the north of the Archæan region and in the upper part of the valley of Four Mile brook (Serpentine).

III.—Hard slates and sand rocks, bent into abrupt anticlines and synclines, in places showing strong induced schistosity and in others presenting a much less altered aspect. This series is wide spread, particularly to the north of the Tobique and has been referred to Silurian age.

IV.—A well marked and persistent, if narrow, bed of conglomerate. The best exposures are seen on the right hand branch of the Tobique, just above the mouth of Jummet brook. It seems to overlie the Silurian slates and sandstones and is to be observed on the crests of the anticlines farther down the river. This rock can be traced from a considerable distance west of these outcrops clear across to the Serpentine and some way up the valley of Four Mile brook on that stream.

V.—Volcanic breccia ? It is a significant fact that this conglomerate is, *in almost every instance*, overlaid by a red spotted rock with an apparent clastic origin ; awaiting the examination of sections it is best described as above, with a query.

VI.—Slates and hard sandstones. This series of rocks follows that last mentioned and is best exposed on the right hand branch of the Tobique to the southward of the breccia. Hand specimens of these rocks are not to be distinguished from the Silurian series, but many fossils are to be found, which are apparently of Devonian age. The fossils are mostly minute and badly preserved but they exactly resemble specimens from the hard Devonian series of England. *Despite careful search no fossils were found in the slates and sandstones to the north of the vicinity of the conglomerate and breccia.* This statement does not mean to the north of Jummet brook, for, as above mentioned, occasional indications of conglomerate were seen almost to the mouth of the right hand branch. As long as any trace of conglomerate was visible occasional fossils were found, but beyond the conglomerate the slates and sandstones are invariably barren. These facts seem to point to a solution of the Devono-Silurian problem.

VII.—Basic eruptives. A belt of rocks of this type crosses the Tobique just above Blue mountain and continues with remarkable persistence, a short distance to the south of the river, to the summit of Falls mountain on the right hand branch. Rocks of a similar kind also occur to the southward across a great valley in which Bald peak forms a conspicuous centre.

Basic eruptives of a more decomposed and amygdaloidal character are seen on the great hills a few miles to the south and west of the mouth of Neary brook on the right-hand branch. This rock also forms the massive hills at the headwaters of Four Mile and Boover brooks on the Serpentine.

VIII—Acid Eruptives—A reddish rhyolite is very characteristic; it forms the whole mass of the Blue mountains and caps many of the hills to east and south of Bald peak. This latter hill is probably of the same nature, but hand specimens show a much darker aspect. These rocks are post-Silurian, possibly post-Devonian in age.

IX.—Pyro-clastic breccia—The whole mass of the Serpentine range is composed of a mottled gray and white rock of clastic origin (?) The brecciated character has been rendered obscure by metamorphism; awaiting microscopic examination, it seems to be a much altered ash rock with brecciated fragments. The same rock occurs at other places and its associations would point to post-Silurian age. Hand specimens almost exactly resemble some of the ash rocks referred to Huronian age by Ontario geologists.

X—Agglomerate—Near the mouth of Irving brook on the main Tobique, and at one point on the lower part of the right hand branch a peculiar rock is encountered; it seems to consist of a basic amygdaloidal eruptive containing rounded fragments of a very similar rock. No conclusions have yet been reached as to the relationships of this example.

It will be seen that an extremely complicated and interesting series of rocks is presented in this region. With one month in the field, and without microscopic sections, the writer has, perhaps, ventured too far in the above notes.

Economic Geology.—The Archæan areas of the Serpentine contain many seams of quartz, but those examined did not look promising. More or less authentic accounts of gold are current among the settlers, and one attempt at mining ended in failure. The only other observations, at all pointing to metallic deposits, were the highly ferruginous character of some of the slates to the eastward of the right hand branch, and a single example of jasper conglomerate in the float near Neary brook.

Work in Charlotte County, N.B.

Mr. Robt. A. A. Johnston.

The early part of the year was occupied in plotting the field-notes of previous years and in assembling information regarding occurrences of meteorites in Canada. Three new meteorites have been reported since the beginning of the present year. Information regarding the finding of these specimens is still incomplete, but it is hoped that this will soon be forthcoming. In other respects, substantial progress has been made with this report.

On the 21st of June, I left Ottawa to resume work in Charlotte county, New Brunswick. A few days were spent in examining a number of localities in the neighbourhood of St. Stephen, about which additional information seemed desirable.

Following this, a survey was made, by means of a Rochon micrometer telescope, of the road from St. Stephen to Brockway, thence by way of Pomeroy Bridge to Little Lake Settlement, and from Pomeroy bridge to the village of St. George. This work was supplemented, as opportunity offered. by examination of various rock outcrops along or near the route travelled. The remainder of the season was employed in investigating the geological and topographical features of the country lying between the Magaguadavic river and the eastern boundry of Charlotte county. This included the measurement of a number of roads, portages and streams, as well as lakes, that had not been previously mapped. In this work I was assisted by Messrs. G. P. O. Fenwick, B. A., and F. E. Bronson. I returned to Ottawa on the 16th of September.

Geological Work in the Northwestern Parts of Nova Scotia.

Mr. Hugh Fletcher.

Mr. Fletcher spent the winter of 1904-05 in the usual work of the office, assisted by Mr. J. A. Robert and A. T. McKinnon.

He left Ottawa on June 7 to continue surveys in Nova Scotia and remained there until January 25, 1906. In the fieldwork he was again assisted during August, September and October by Mr. McKinnon ; for three months by Mr. Harold F. Tufte, of Wolfville, and for two months by Mr. James McG. Cruikshanks, who has been with Mr. Faribault for eighteen years, and whose skill and energy were utilized to define the folds of the complicated rocks which underlie the Horton series south of Kentville and Wolfville. With him also from September 18 to the close of the season was Mr. N. D. Daru, of Surat, India.

Mr. McKinnon was engaged in a survey of southern Kings and Annapolis and of northern Lunenburg, a district lying north of the old Dalhousie road, bounded on the east and north by New Ross and Lake George, and on the west by the Halifax and Southwestern railway. Within this district lie large barrens, and the woodlands are intersected by the tote-roads of the Davidson Lumber Company. The eastern part was fully surveyed, while to the westward all available roads connecting large lakes and streams with the main roads were chained. Gray granite is the prevailing rock, but along the southern boundary 'whin' debris appears and 'whin' is perhaps in place at Lake Torment.

In June, Mr. Fletcher made examinations to define more clearly certain geological boundaries on Map-sheets 59 to 62 of Cumberland county, which have been coloured and will be ready for distribution in a few days.

Further surveys were next made along the Kennetcook river to complete Sheets 64, 65, 73 and 74, which are now in the hands of the printer, so that the results of these surveys need not here be adverted to. A white quartzose sandstone from Northfield, near Mr. Jacob Hennigar's, was examined by Mr. Charles Fergie and proved suitable for the manufacture of fire bricks. The strong salt springs and the limestone quarries of the neighborhood have been already mentioned. The manganese mines of Tennycape were worked last year by Mr. Mortimer Parsons on a lease of ten per cent royalty. The lump ore brings about $100 per ton, while for the finer material it is hard to find a sale. In the neighborhood of Kennetcook Corner and on the Noel road many blocks of pyrolusite lie apparently near the contact of the Carboniferous limestone and Horton rocks, but their source has not yet been uncovered.

Large shipments of gypsum were exported last summer from Wentworth, Walton and other quarries. Samples of limestone from the quarries at Walton and Tennycape were collected by Mr. William Stephens and Mr. Parsons and sent to Dr. Hoffmann for analysis. Quarries of rough sandstone for building have been opened recently at Doddridge and other places on the Midland railway.

Some time was spent in defining more precisely the boundaries of the various geological formations to the westward of Three-mile Plains for Sheets 84, 85, 98 and 103 of Kings and Annapolis counties. These formations comprise Granite, Cambrian, Cambro-Silurian, Silurian, Devonian, Carboniferous Conglomerate and Carboniferous Limestone, described in the Summary Report for 1901, pages 209 to 214, and illustrated by a map. Most of the details of this work, which is still incomplete, are of little immediate interest but will be incorporated with the map. The investigation of the structure of the Horton beds and their relation to the underlying Silurian rocks and to overlying Carboniferous, is of more interest because these Devonian rocks are again being mistaken for coal measures as they were in 1842; conclusions respecting their geological age being again founded on their organic contents. For the reincarnation of this error of more than sixty years ago there seems to be no reasonable justification.

In some of these investigations Mr. Fletcher was aided in September and October by Dr. R. W. Ells and Mr. E. R. Faribault, whose intimate knowledge of the rock formations was of great value in their correlation; he accompanied Dr. Ells to Lepreau and other places in New Brunswick, and at Canterbury and Benton they were fortunate in having the co-operation of Professor L. W. Bailey of the University of New Brunswick who pointed out many features of interest in the structure of the rocks.

The so-called iron mines of Lepreau are on small, irregular, unimportant veins of magnetite in gneissic rocks which have been intermittently exploited for many years. During the last two or three years, under the guidance of a magnetometer, several vertical and slanting boreholes have been drilled to a depth of from 200 to nearly 1,000 feet in an endeavor to locate larger veins of iron ore.

On Sept. 28 in company with Dr. Ells another collection was made of the *Fenestella* of Messenger brook which was sent to Dr. Rudolf Ruedemann, assistant palæontologist of the State of New York, who was greatly interested in the mode of preservation of these fossils. There are, he reports, impressions which look like a *Dictyonema* at first glance, but these are connected by transitional states of preservation with distinct *Fenestellæ*, preserved in relief casts. On closer examination also the completely flattened specimens, looking so much like *Dictyonema*, show features that betray this fenestelloid character, as he thinks. They show regular rows of pores, the dissepiments are much thicker than in *Dictyonemæ*, as a rule, and so constructed that the lumina of the meshes are oval in form; while in *Dictyonema* they are always rectangular. Besides the meshes are more regular than in any *Dictyonema* known to him. Some of the lamellibranchs and brachiopods have been reduced to a like black film. Dr. Ruedemann has become a little suspicious by this interesting occurrence as to the graptolite nature of the mineral of *Dictyonema webesteri* which always occurs in similar glazed or much compressed shale and also is reported as differing from other *Dictyonema* by its very regular meshes.

Dr. Ruedeman had previously also made a careful comparison of many specimens of *Dictyonema websteri* with authentical material of *D. retiforme*, from the Niagaran shale in New York, which fails to show any difference sufficient for specific distinction, and he had, therefore, come to the conclusion that *D. websteri* is identical with *D. retiforme.*

Among the fawn-coloured shales underlying the Silurian rocks of Canaan *Dictyonema* has been found in nearly all the brooks, from Harding (Angus) brook below Gaspereau village to Sharpe brook south of Cambridge station. In Duncanson brook thir fossil was collected last summer by Mr. N. D. Daru who also obtained from Elderkinbrook, and other streams in the neighborhood of Kentville and Highbury, smooth and corrugated burrows or trails of annelids of considerable size. In Harding brook, as already stated, *Dictyonema* is associated with a form like *Bryograptus* ; near Highbury, with a *Phyllograptus ?* discovered by Messrs. Cruickshank and Tufts ; and west of the Deep Hollow road near Port Williams, with encrinites. The *Dictyonema* of Sharpe brook was found in abundance above a twenty-feet fall, in several contiguous layers of reddish and gray somewhat sandy shale.

After October 11, some weeks were spent in the neighborhood of Torbrook mines, where work is being vigorously prosecuted by the Londonderry Company, to trace the various bands of diorite and granite and belts of slate and quartzite. This work seems to prove that the rocks lie in several synclines, one of which is crossed in the mine workings, about ninety feet from the Leckie ore-bed, by a tunnel driven south from No. 3 level about 200 feet from the surface near the Woodbury shaft ; but ore has not yet been found on the south side of the basin. Down the Woodbury shaft the ore was followed to a vertical depth of about 314 feet ; in the main shaft, to 265 feet, and at the Seary shaft to 210 feet, giving a westerly pitch of about 10° to the bottom of the ore-basin. At 162 feet from the ore-bed in the above mentioned tunnel from No. 3 level west, a borehole was drilled 346 feet at an angle of 77°, or at right-angles to the ore in the shaft, and from the same point another hole was drilled 67° for 136 feet, but neither of them cut the ore. Two holes were also bored on No. 5 level, about 310 feet from the surface : No. 1, horizontally or at right-angles to the ore-bed for 192 feet into strata underlying the Leckie bed, and No. 2, in the east end of No. 5 level, for 96 feet running easterly at an angle of 45°. The Nova Scotia Steel Company also expended considerable money last winter in making borings.

In addition to the ore obtained at the Leckie mines, several car-loads were mined in the Bloomington district and shipped at Nictaux station by the Londonderry company, which, having taken an eight months' option of the properties held by Messrs. Brookfield and Corbitt, has put down two new exploratory shafts on the shell ore-bed. One of these is about a mile west of the Woodbury shaft, on the farm of Melbourne Hoffman, and the other about one mile and three-quarters west of the Woodbury shaft, at Fletcher Wheelocks. From the bottom of both tunnels were driven to the Leckie bed. A line of railway was also surveyed from the Leckie mines to the new shafts.

At the Hoffman shaft, which is 14 by 7 feet and 163 feet deep, a power-house, a lodging house and other buildings have been built. A 60 horse-power return tubular boiler, a hoisting engine and air-compressor have been installed, also a Knowles vertical pump.

. The Fletcher Wheelock shaft is of the same size and the equipment about the same as at the Hoffman shaft. After following the ore dipping 77° for 64 feet, it flattened to 54° for about 15 feet, then to 34° for 16 feet, the ore thickening to about 12 feet. The rocks then dip 75° southward as before, but at about 21 feet below the bend the ore pinched out, and at 7 feet farther in the rock the dip changed to the northward at an angle of 75° to 80°. The shaft was continued to a depth of 170 feet, the last 54 feet in rock upon the line of the 75° southward pitch. Both shafts were sunk by Messrs. Patterson and Hyde of Pittsburg, who had previously put down the Allan shafts near Stellarton. To Messrs. Hyde, Parsons and Weir, Mr. Fletcher is indebted for most of the above information and for other kindness.

By request of Mr. A. Johnston, M.P., two visits were made to the Sydney coal field, to inspect explorations carried on by the Dominion Coal Company and others, in search of the Mullins seam, in the neighborhood of Lynk (Hayes) lake and Southwest brook, at the head of Lingan basin. On his second visit, about the middle of January, 1906, Mr. Fletcher accompanied Mr. Patrick Neville, under whose charge these explorations had been made during the preceding summer. The first plan suggested by the engineers of the Dominion Coal Company, to bore with a calyx drill so as to cut all the coals from the Clarke seam downward, had not been carried out ; but several pits and boreholes had been put down near Lynk lake, and a coal seam found on the south side of the lake, which was assumed to be that bored by Burrows near the outlet and subsequently exposed in a shaft nearby, and also to represent, although not actually traced, a seam opened on the southwest brook at or near the horizon of the Martin seam, with which it might thus be identical.

Since the question of the extension of the Mullins seam in this direction has not yet been solved, it is perhaps desirable that borings like those made near Springhill should be undertaken to trace the outcrop from the borehole south of Lynk lake and determine whether that coal runs to the neighbourhood of the Martin seam on Southwest brook, as supposed by Mr. Neville ; to trace a coal seam or some well defined rock band from the Routledge pits near the west end of Lynk lake westward or southward around the basin ; and also to follow the Tracy seam from Broughton colliery northward towards the fork of the Cowboy and Macpherson roads, to Grand lake and Sydney harbour. It seems possible that a small fault follows the anticline between the Glace Bay and Lingan coal basins, the delineation of which with reference to the submarine workings of Dominion No. 1 colliery seems to warrant the expenditure necessary ; and in any case it is important to determine the position and nature of the anticline which must affect the submarine workings of that and other collieries. The surface does not seem to be deep, clay-shales and other rocks being found at no great depth, consequently these explorations should not cost much in comparison with the advantage of having once for all defined the structure of this part of the coalfield.

Boring was continued by the Standard Coal Company in Cumberland county and the same tools and derrick with which the borehole was put down at Pettigrew were used for a second hole on the shore of Fullerton lake about 275 yards south of the saw-mill at Newville station. Drilling was begun in a mixture of red clay or mud and very fine sand of the consistency of slime, resting at 87 feet upon bedrock covered by great blocks among which the casing collapsed at 75 feet. This hole was accordingly abandoned and the drill moved to higher land a short distance northeast of Newville station where a hole was begun which has now reached a depth of about 900 feet and is still in conglomerate. At 808 feet the bit was lost by a break in a welding and drilling had to be suspended until fishing-tools were obtained from Pennsylvania by which it was recovered.

The Rear brook borehole was carried to a depth of nearly 3,100 feet without, however, reaching the bottom of the conglomerate which includes layers of reddish or purplish argillaceous shale and sandstone. Much of the debris resembles Millstone grit but is apparently derived from a conglomerate like that of New Glasgow bridge in which there are many large pebbles of this rock.

Mr. Isaac McNaughton's borehole north of Trenton was continued to a depth of about 700 feet in strata similar to those found higher.

Gold Fields of Nova Scotia.

Mr. E. Rodolphe Faribault.

Mr. Faribault was engaged in office work at Ottawa from October 6, 1904, until June 20, 1905, when he left for field work in Nova Scotia and returned to Ottawa on October 14, 1905.

The greater part of the time passed in the office was spent in plotting surveys, made the previous summer by him, and in revising the plotting of surveys, made by his assistants, of the gold mining districts of Leipsigate, Malaga and Brookfield and the country surrounding them, in the counties of Lunenburg and Queens, as detailed in the Summary Report for 1904, pages 320 to 332.

Special plans of the gold mining districts of Leipsigate, Malaga, Brookfield and Clam Harbour were also compiled on the scale of 250 feet to one inch, and these plans with that of Miller lake surveyed in 1903, are now completed and only require to be traced for publication.

The large scale plan of the gold mining district of Harrigan Cove, surveyed in 1901 and reported on in the Summary Report for that year, page 416 to 419, is now being engraved.

Good progress was especially made this year in the compilation of the one-mile to an inch map from the surveys executed for several years past in the counties of Halifax, Hants and Lunenburg. The greater part of this compilation was made by Major F.

O'Farrell, who joined this department on October 24, 1904, and has since then been continuously engaged in carrying out this work, which has been so long in arrears. The area compiled extends along the Atlantic shore from the head of St. Margaret bay to Mahone bay, and as far north in the interior as Mount Uniacke, Newport and Windsor, and includes all the rivers flowing south into St. Margaret bay and Mahone bay, and the Ponhook lake and St. Crois river flowing north into Minas basin. This region is covered by the map sheets of Windsor, Ponhook lake, St. Margaret bay, Aspotogan and Mahone bay, each measuring 18 inches long by 12 inches wide. It is estimated that with the assistance now received in a little over one year the office work will have caught up to the field work.

Much of Mr. Faribault's time was taken up in correspondence, especially in answering letters from persons seeking information and advice on the gold fields of Nova Scotia, which are attracting much attention at the present time in connexion with deeper mining.

Advice and reports have also been given, by special request, to the Government of Nova Scotia regarding the advisability of extending government assistance to certain companies in the sinking of deep shafts in certain gold mining districts, for which the provincial legislature passed an Act at its session of 1903, offering to bear half the expense of the actual sinking from the surface to a vertical depth not exceeding 2,000 feet.

On the field work accomplished in the Nova Scotian gold fields during the summer of 1905, Mr. Faribault reports as follows:—

In accordance with your instructions, I left Ottawa with Major O'Farrell on June 20, 1905, for Elmsdale, Nova Scotia, where I was joined by my field assistants, Messrs. J. McG. Cruickshank and A. Cameron, who have now been with me for nineteen and eighteen years respectively. Major O'Farrell continued under my supervision the compilation of the manuscript map, while my other two assistants were engaged in field work the whole season, until the end of October.

The greater part of my time was devoted to the revising of the geological structure of the gold-bearing rocks to the east and north of Halifax, included in the map sheets of Lawrencetown, Musquodoboit harbour, Gays river, Renfrew and Windsor, as well as the northern part of the Waverly sheet, in order to complete and have them ready for publication. The surveys of that region were made several years ago, but owing to pressure of office work were compiled only recently. In this work I was ably assisted the whole season by Mr. Cruickshank and the latter part of the season by Mr. Cameron, both of whom were entrusted with the revision of the topography in order to bring it up to date. The surveys were plotted and transferred immediately to the manuscript map from week to week as the work progressed, and this method proved very satisfactory for working out the structure with more accuracy and detail.

This region is for the most part underlaid by the slates and quartzites of the gold-bearing rocks. Towards the east and west these rocks are replaced by granite, which also forms a small isolated patch to the southwest of Wellington station. The gypsum and limestone of the Lower Carboniferous are predominant about Windsor and Newport, where gypsum quarries are extensively worked, and they form irregular basins along the valleys of the Shubenacadie, Nine Mile, Gay and Musquodoboit rivers, where quarries of limestone, gypsum and selenite have also been worked on a small scale, and deposits of bog iron ore have been prospected recently.

In the gold bearing area examined are included the gold mining districts of Lake Catcha, Lawrencetown, Oldham, Renfrew, Mount Uniacke, and South Uniacke, detailed plans of which have been published on a large scale ; also those of Cow Bay, Rawdon, East Rawdon, Ardoise, Meander River and the celebrated antimony-gold mines of West Gore. Most of these were at one time or another the centres of important mining operations, but with the exception of West Gore, Oldham and Mount Uniacke which are still producing, they are now for the most part inactive.

Since my return to the office, the Lawrencetown, Musquodoboit Harbour and Gay River map-sheets were completed and they are now being published ; while those of Elmsdale, Windsor and Ponhook will be ready for publication in the spring, before field work is resumed. It is intended, next summer, to push vigorously the revision of the Waverley, Halifax, Prospect, Ashpotogan and St. Margaret Bay sheets, in order to have them completed by the end of the year.

Progress was also made in the general survey of the western counties, by Mr. Cameron during the first three months of the season. He completed the odometer survey of all the roads in Queen's county and began those in the sontheastern part of Annapolis county. He also surveyed the headwaters of Lahave river, as far north as the old Dalhousie road and west to the line of the Halifax and Southwestern railway.

The Nova Scotia government engaged last summer Mr. T. A. Rickard, mining engineer, to report on the gold fields of the province and the possibility of developing them successfully on a larger scale and to greater depth. At the request of the provincial government and with the authorization of Dr. Bell, I spent three weeks in August, with Mr. Rickard, making a general examination of the most important gold mining districts. The following districts were visited : Montague, Waverley, Oldham, Renfrew, Mount Uniacke, Caribou, Dufferin, Harrigan Cove, Goldenville, Cochran Hill, Country Harbour, Isaac's Harbour. Seal Harbour, Forest Hill, West Gore, Leipsigate and Brookfield. Valuable information and data have thus been collected and many interesting photographs taken which will be useful in bringing up to date my final report, now in preparation, on the gold fields of the province.

Chemistry and Mineralogy.

Dr. G. C. Hoffmann.

In reporting on the work done in these branches of the Survey's operations, Dr. Hoffmann says:—

"The work carried out in the chemical laboratory has been upon the usual lines, that is to say, it has been almost exclusively confined to the examination and analysis of such ores and minerals, etc., etc., as were deemed likely to prove of economic value and importance. Briefly summarized it embraced:

"1. Analyses of different varities of fossil fuel from various parts of the Dominion, namely of—Lignite, from a deposit in Tp. 63, on or near Towtinow river, some eighteen miles south-southwest of Athabaska landing, Alberta. Lignitic coal from tunnel on the Jackson seam on Quilchena creek, five miles from its entry into Nicola lake, Yale district, B.C. Coal from a five-foot seam at the head of Snow creek, between Panther and Red Deer rivers, Alberta, from a seam on the east fork of Pine river south, also from a seam on Cañon creek, Pine river south, and from a seam on Coal brook, Pine river south, Cariboo district, B.C.; from outcrops near the junction of the Coldwater and Nicola rivers, Yale district, B.C.; anthracite coal from the Costigan seam and underlying seams, Panther river, Alberta, and from Sheep creek, Alberta; semi-anthracite from the same Costigan seam, and from the lower seam on Goat river, Telqua river, Bulkley river, Cassiar district, B.C.

2. Analyses, more or less complete, of several varieties of iron ore, namely, of magnetite, from the property of W. R. Neily, close to the Leckie mine, Torbrook mines, Annapolis county, N.S.; from a point three miles west of Clarendon station, parish of Clarendon, Charlotte county, N.B.; from a point on the Rivière des Quinze (Ottawa river), Pontiac county, Que.; from the northwest branch of the Gatineau river, Que.; from the vicinity of Lake Temagami, Nipissing district, Ont. Hematite, from the property of John F. Yeats, on lot 6, range 1, Durham township, Missisquoi county, Que.; and from the property of Levi J. Blake, Pinnacle mountain, Missisquoi county, Que. Clay iron-stone, from sections six and seven, of township 10, range xxi, west of the fourth initial meridian, Alberta.

3. Analyses, partial, of copper ore from a shaft sunk in the Triassic trap at Wellport, Digby county, N.S.; La Tête, Charlotte county, N.B.; Orford township, Sherbrooke county, Que.; the north-half of lot 3, concession iv, Kent township, Nipissing district, Ont.; mining location No. 2961, range 455, northeast of Schreiber, Thunder Bay district, Ont; and from the Europa claim No. 14, Britannia mountain, Howe sound, B.C.

4. Analyses, more or less complete, of limestones and dolomites (being a continuation of the series of analyses of such stones already carried out in connexion with an

inquiry into their individual merits for structural purposes, for the manufacture of lime, or of hydraulic cement, or for metallurgical purposes, &c.), including limestone from three miles east of Brookfield, Colchester county, N.S.; from Dewars Hill, west side of Pugwash harbour, Cumberland county, N.S.; from near Lake Mercier, Labelle county, Que.; from the quarry of Mr. Beaulieu, on Little Mascouche road, Ste. Anne des Plaines parish, Terrebonne county, Que.; from lot 5, and range iv, Grenville township, Argenteuil county, Que,; from Rudd's quarry, Barriefield, Pittsburgh township, Frontenac county, Ont.; and from Peterborough township, Peterborough county, Ont. Dolomite, from lots 1 and 4, range v, Wentworth township, Argenteuil county, Que. and from near Lake Mercier, Labelle county, Que.

5. The examination, in many instances accompanied by a more or less complete analysis, of samples of clay, from numerous localities, in regard to their suitability for the manufacture of bricks, tiles, sewer-pipes, terra-cotta, stone-ware, &c., the localities including the vicinity of Baddeck, Victoria county, N.S.; material from the farm of Angus McLean, French Vale, Cape Breton county, N.S.; clays from Cumberland county, N.S.; from a boring two miles east of 'The Brook' village, Clarence township, Russell county, Ont.; from a boring, lot 10, concession iii, Sarawak township, Grey county, Ont,; from an extensive deposit on section 28, township xii, range xxiv, west of the second initial meredian, Saskatchewan; from the homestead of Mr. A. M. Kay, on the northeast quarter of section 34, township xxxii, range 1, west of the fifth initial meridian, Alberta; from a bed on the north-half of section 11, township xxix, range xxiii, west of the fourth initial meridian, Alberta; from Kildonan, near Winnipeg; from the west half of section 19, township vii, range iii, west of the fifth initial meridian, Alberta; from Prairie creek, Clearwater river, Alberta; and from the mountain three miles east of Enderby, Yale district, B.C.

6. Analyses of natural waters carried out with the object of ascertaining the suitability of the same for domestic or manufacturing purposes, or probable value as a remedial agent, from, respectively, a boring at Rear brook, East River, Pictou county, N.S.; from the mine of the Souris Coal Mining Company, Souris district, Saskatchewan; from a spring near Bakers or Carrington lake, on the east side of Moose mountain, Saskatchewan; from wells at Whitewood and Ingram, Saskatchewan; from a well on the property of Mr. Archibald, on section 30, township liii, range xxiii, west of the fourth initial meridian, Alberta; and from a spring on the bank of Shuswap river, about eight miles north of Enderby, Yale district, B.C.

7. Miscellaneous examinations. These include the examination, accompanied in most instances by a partial analysis, of specimens of:—Argillaceous shale, bitumen, bituminous shale, bog iron-ore, carbonaceous shale, deposits from springs, ferruginous shale, graphite, graphitic-schist, iron-ochre, manganese ore, marl, molybdenite, pyrophyllite, pyroschist, silt and talc-schist.

A very careful examination has also been made of a sample of the sand in the final washing of the material obtained in dredging for gold in the Fraser river, two miles below Lillooet. This sand, it was found, contained, in addition to flattened grains of native gold, scales of native platinum, and grains of iridosmine, also some small grains of a native iron-nickel alloy, to which the name 'souesite' has since been given by the writer, having, in the pure condition, the following composition :—Nickel 76·48, iron 22·30, copper 1·22 = 100·00. Should this material be obtainable in any quantity, it would, it need scarcely be said, be valuable as a source of nickel.

During the period covered by this report, 628 mineral specimens were received for identification or for the purpose of eliciting information in regard to their economic value. Very many of these were brought by visitors, and the information sought in regard to them was not infrequently communicated to them at the time of calling. In other instances—those where a more than mere cursory examination was called for, or when a partial or even complete analysis was deemed desirable—the results were, as in the case of those specimens which had been sent from a distance, communicated by mail. The correspondence in this connexion called for the personal writing of 327 letters, many of which constituted lengthy reports ; whilst the number of letter received; in the same connexion, amounted to 110.

'The successful carrying out of the work above outlined, is, I have much pleasure in acknowledging, in no small measure due to the assiduity and zeal displayed by assistant chemist and mineralogist, F. G. Wait, who has at all times manifested great interest in the work of the laboratory.

'The additions to the mineralogical and lithological section of the Museum during the past year, embraced :—

A.—Duplicates of Specimens which were sent to the Laboratory for Examination.

Clay, from a deposit on section 28, township xii, range xxiv, west of the second inital meridian Saskatchewan.

Clay iron-stone, from sections 6 and 17, township x, range xxi, west of the fourth initial meridian, Alberta.

Hematite, from lot 6, range i, Durham township, Missisquoi county, Que.

Molybdenite, in foliated masses, distributed through a gangue composed of quartz, feldspar, and a little hornblende, from lot 6, range xii, Eardley township, Wright county, Que.

Molybdenite, fine-granular massive, in a matrix of quartz, from one of the Tamaric group of claims on Gnawed mountain, Yale district, B.C.

Talc, from lot 683, in No. 2 Craig's Road Range, Ireland township, Megantic county, Que.

B.—Collected by Members of the Staff engaged in Field-work in connexion with the Survey.

Barlow, Dr. A. E. :—

Twenty specimens, consisting of smaltite, niccolite, and silver-bearing ores, from various mines and prospects in the cobalt-nickel-silver mining area, Coleman township, Nipissing district, Ont.

Ingall, E. D., all from Coleman township, Nipissing district, Ont. :—

(*a.*) A specimen of disseminated native bismuth from the Timiskaming and Hudson Bay Mining Company's mine, on lot 7, concession 5.

(*b.*) A specimen of erythrite from the Savage mine, near the southern end of Carl lake.

(*c.*) A specimen of a leafy form of native silver in the matrix, from the Trethewey mine, location J. B. Y.

Johnston, R. A. A. :—

Two specimens of an incrustation of radiating fibrous malachite from the Seattle claim, Iron mountain, Yale district, B.C.

Low, A. P. :—

Crystals of pyrŏxene found, as a secondary mineral, in a soft, light green weathering, green chloritic-schist resulting from the alteration of diabase occurring on Chibougamau river, six miles below the junction of Brock river, in the northern part of Quebec.

McConnell, R. G., B.A. :—

(*a.*) A nugget of native copper from Burwash creek, Kluane river, a stream flowing out of the northern end of Lake Kluane, Yukon Territory.

(*b.*) Pellets of native silver from the same locality as the preceding.

Parks, Professor W. A. :—

All from Coleman township, Nipissing district, Ont.

(*a.*) Six specimens of native silver, eleven specimens of niccolite with native silver, and three specimens of smaltite, from the La Rose mine.

(*b.*) Fifteen specimens of smaltite, nine specimens of smaltite with erythrite, two specimens of native silver, three specimens of smaltite with native silver and two specimens of niccolite with native silver, from the Ferland and Chambers mine.

(*c.*) One specimen of smaltite with native silver from the McKinley and Darragh mine.

Poole, R. S., M.A. :—

The following specimens from Vancouver island : A specimen of coal coked by andesite, Brown river, Comox ; a specimen of coal coked by andesite, Cumberland ; a specimen of lower shale, near contact, Nanaimo river ; an association of coal and andesite from outlet of Comox lake ; a specimen of floor rock, trap, and shale with attached coal ; two nodules of coal from lower seam near Protection island shaft.

Willimott, C. W. :—

A crystal group of nephelite from lot 25, concession 14, Dungannon township, Hastings county, Ont.

(C.—By presentation.)

Bèlanger, Joseph :—

A specimen of auriferous quartz from a vein about three miles north—northeast of Michipicoten Mission, north shore of Lake Superior, Thunder Bay district, Ont.

Boisvert, Alex., per Dr. H. M. Ami, (Survey):—

A sample of shell marl from a deposit covering fifteen acres and having an average thickness of three feet—in part on lot 2 and in part on lot 3, of range vii Bouchette township, Wright county, Que.

Charest, A.:—

Concretionary nodules found on the shore of a small unnamed lake a few miles northeast of Lake Kiemawist, Abitibi district, Que.

Plant, James E., of Charlottetown, Prince Edward Island:—

A fragment of a massive, radiating, fibrous limonite from Grindston eisland, one of the Magdalen group, Gulf of St. Lawrence.

Latchford, Hon. Frank R.:—

(a) A specimen of erythrite, a specimen of an intimate mixture of smaltite and cobaltite with a little native silver and a specimen of smaltite with some cobaltite from the vicinity of Cobalt, Ont.

(b) Model of the Proton meteorite, found near Proton station, Grey county, Ont.

Morrison, Thos., of Bancroft, Ont.:—

A specimen of sodalite with hydronephelite, from lot 25, concession 14, Dungannon township, Hastings county, Ont.

Morrison, William:—

Two samples of clay, one from a bed on lot 10, and the other from a bed which is partly on lot 10 and partly on lot 11, of concession 3, Sarawak township, Grey county, Ont.

Nattress, Rev. Thomas, per Dr. J. F. Whiteaves (Survey):—

A fragment of a nodule of grayish-white to white, opaque, dull, chert or hornstone, found in a brownish-gray fossiliferous dolomite met with in cutting a channel in the bed of the Detroit river at Amherstburg, Malden township, Essex county, Ont.

Soues, F., Gold Commissioner, Clinton, B.C.:—

(a) A specimen of stibnite from a quartz vein at the southeast end of Chilco lake, New Westminster district, B.C.

(b) A sample of sand obtained in dredging for gold in the Fraser, near Lillooet, B.C.

Winning, P. B., per Mr. R. L. Broadbent:—

Specimens of black spinel, in the matrix, from lot 52, range 2, Bigelow, Labelle county, Que.

(D.—By Purchase.)

Through Dr. Robert Bell:—Seven specimens of rich native silver-bearing ores' from the Trethewey silver cobalt mine, Coleman tp., Nipissing dist., Ont.

Through Dr. A. E. Barlow :—Two nuggets of silver from the New Ontario mine, location J.B.Y., east side of Sasaginaga lake ; and a nodular mass of native silver-bearing ore, weighing two hundred and fifty-seven pounds, and containing, approximately, twenty per cent of native silver, from the La Rose mine, Cobalt, Ont.

Mr. C. W. Willimott has devoted considerable time to the making up of collections of minerals and rocks for various Canadian educational institutions. The following is a list of those to which such collections have been sent :—

		Specimens.
1. Public School, Cornwall, Ont., consisting of..		75
2. Summer School of Science, Kensington, P.E.I., consisting of		75
3. Public School, Shelburne, Ont.	"	75
4. Winter Street School, St. John, N.B.	"	75
5. Albert Street School, St. John, N.B.	"	75
6. County Academy, Port Hood, Inverness county, N.S.	"	100
7. Graded School, Norton, N.B.	"	75
8. High School, Forest, Ont.	"	75
9. Public School, East Toronto, Ont.	"	75
10. High School, Gravenhurst, Ont.	"	100
11. Public School Board, Dunnville, Ont.	"	100
12. High School, Kincardine, Ont.	"	100
13. Superior School, North Head, Grand Manan, N.B.	"	100
14. Sapperton School, Sapperton, B.C.	"	75
15. High School, Thorold, Ont.	"	100
16. Academy, Inverness, Que.	"	100
17. High School, Simcoe, Ont.	"	100
18. Model School, Athens, Ont.	"	100
19. Public School, Palmerston, Ont.	"	75
20. High School, Cornwall, Ont.	"	100
21. St. Joseph's Academy, St. Hyacinthe, Que.	"	75
22. High School, Nanaimo, B.C.	"	100
23. Collegiate Institute, St. Marys, Ont.	"	100
24. High School, Athens, Ont.	"	100
25. Public School, Chatsworth, Ont.	"	30
26. High School, Glencoe, Ont.	"	100
27. St. Bernard College, Sorel, Que.	"	100
28. Sisters of the Congregation of Notre Dame, Quebec	"	75
29. High School, Niagara-on-the-Lake, Ont.	"	100
30. High School, Walkerton, Ont.	"	100
31. Natural History Association, Chatham, N.B.	"	100
32. High School, Welland, Ont.	"	100
33. Model School, St. Thomas, Ont.	"	100
34. Macdonald's Consolidated School, Kingston, N.B.	"	100
35. Public School, Pointe aux Trembles, Que.	"	100
36. High School, Sterling, Ont.	"	100
37. London Historical Society, London, Ont.	"	82
38. High School, East Toronto, Ont.	"	100
39. St. Jean l'Evangeliste Acadamie, Point St. Charles, Que.	"	75
40. High School, Almonte, Ont.	"	100
41. St. Vincent de Paul, Brockville, Ont.	"	75
42. Douglas Avenue School, St. John, N.B.	"	75
43. Convent Jesus Marie, Beauceville, Que.	"	75
44. Jameson Avenue Collegiate Institute, Toronto, Ont.	"	100
45. Young Men's Christian Assn., Charlottetown, P.E.I.	"	100
46. Dept. of Mineralogy, University of Toronto, Toronto, Ont.	consisting of..	5

In addition to which, collections have also been made up and forwarded to the :—

	Specimens.
Canadian Commercial Agent in Paris, France, consisting of	62
Exhibition Branch of the Department of Agriculture, Ottawa, consisting of	12
University of Virginia, Charlotteville, Va., U.S.A., consisting of	6

Making in all a total of 4,097 specimens of minerals thus distributed.

Mr. Willimott also visited a number of mineral localities, during the summer months, for the purpose of collecting further material for the making up of collections of the nature of those above referred to. While so engaged he procured several hundred-weight of each of the following :—Calcite ; chrome garnet in the matrix ; diopside ; hematite ; magnesite ; pyrite ; pyrrhotite ; and serpentine. Also numerous specimens of limestone, dolomite, and serpentine, suitable for use as a marble. These latter he will cut and polish and, later on, report upon in regard to their relative merits for decorative purposes.

Palæontology and Zoology.

Dr. J. F. Whiteaves.

Dr. Whiteaves reports that the manuscript of the fourth and concluding part of Palæozoic Fossils, Vol. III., which was commenced last year, has been completed, and an index to the whole volume has been prepared. This part of the volume consists of four papers, as follows :—

(1) 'The Fossils of the Silurian (Upper Silurian) rocks of Keewatin, Manitoba ; the northeastern shore of Lake Winnipeg and the lower part of the Saskatchewan river.'

(2) 'The Canadian species of *Plectoceras* and *Barrandeoceras.*

(3) 'Illustrations of seven species of fossils from the Cambrian, Cambro-Silurian, Silurian and Devonian rocks of Canada.'

(4) 'Revision of the nomenclature of the fossils of the Guelph formation of Ontario.

One-half of the first of these papers and the whole of the second and fourth were written in 1905, the third being little more than a reprint of previously published, but not illustrated, descriptions. The part, as a whole, is to be illustrated with eighteen full-page plates and eight text figures, the drawings for which are now being reproduced. As soon as proofs of these reproductions are received, the explanations of the plates can be written and the letter press sent to the printer.

Two small collections of Cambro-Silurian fossils from Ontario, viz., one from Kingston Mills and one from Campbellford, and two from the Vancouver Cretaceous, have been examined and reported on. Information about Canadian fossils, or zoological specimens, has also been, as usual, given or sent to various applicants.

In the department of zoology, small collections of land and fresh water shells, made in 1905 at various localities in Keewatin, Quebec, Ontario and British Columbia, have been named for W. McInnes, O. O'Sullivan, A. P. Low, Prof. Macoun, and J. M. Macoun. And, in this connexion, the whole of the recent Canadian *Cycladidæ* in the Museum of the Survey has been sent, in instalments, to Dr. V. Sterki, of New Philadelphia, Ohio, who has made a special study of this difficult group of fresh-water bivalves. These specimens have been kindly and gratuitously determined by Dr. Sterki, who recognizes twenty species of *Sphærium* and eighteen of *Pisidium* (or *Corneocyclas*), or more than double the number that were previously known as occurring in Canadian waters.

At the request of Dr. H. Kluge, nearly the whole of the recent *Bryozoa* from the Atlantic and Pacific coasts of Canada, in the Museum of the Survey, have been sent to Berlin for further study and comparison.

Six short papers on Canadian zoological subjets have been written in 1905, and published in various scientific journals. Four of these papers are lists of the species represented in small collections of land and fresh-water shells from Keewatin, Yukon, and several other widely distant localities. The fifth is an illustrated description of a new *Gomobasis* (a fresh-water shell) from Upper Columbia lake, B.C., collected by Mr. J. B. Tyrrell in 1883; and the sixth records the capture of a specimen of the Banded Pocket-mouse (*Perognathus fuscus*) in Manitoba. A bibliography of Canadian Zoology for 1894, exclusive of entomology, has been prepared and has been printed in the Transactions of the Royal Society of Canada for 1905.

During Dr. Bell's absence from Ottawa, for a little over two months last summer, the duties of Acting Deputy Head and Director were performed by the writer. In addition to letters written or dictated in that capacity, the writer's official correspondence in 1905 consisted of 194 letters received and 168 written.

The following specimens were received in 1905, either from members of the staff or from employees of the department:—

Professor Macoun:—

A collection of fresh water shells from the St. Lawrence river near Quebec, and of marine shells and sponges from Cap à l'Aigle, Charlevoix county, Que.

Fletcher, Hugh:—

Several specimens of *Dictyonema* from brooks south and east of Kentville, Kings county, and from Spinney brook, Annapolis county, N.S.; also some shales with plant stems from the latter place.

Ells, Dr. R. W.:—

A few fine specimens of marine shells from the Queen Charlotte islands.

McConnell, R. G.:—

Manotis suborbicularis and two other fossils from Cañon Burwash creek, Kluane district, Yukon territory.

Low, A. P.:—

Small collection of fresh-water shells from northern Quebec.

Ami, Dr. H. M.:—

About 400 fossils from the Trenton limestone at the Montmorency river, P.Q., and 150 from the marine Pleistocene clays at Besserers, Ont. Large collections of Silurian and Devonian fossils from St. Helens island, Montreal, made for Dr. Ami by Mr. Edward Ardley.

Lambe, L. M.:—

Large collections of fossils from the Lower Helderberg rocks at Cap Bon Ami, N.B.; also a few fossils from rocks of the same age behind Point Fleurant, P.Q., and from Black Cape, about three miles east of the Cascapedia river, Que.

A few specimens of fossil fishes from the Lower Devonian rocks at Campbellton, N.B., and a large collection of fossil fishes and plants from the Upper Devonian rocks near West Maguacha, Scaumenac bay, P.Q. Some recent marine sponges, a few land shells and a small specimen of *Plethodon cinereus* from West Maguacha.

McInnes, W.:—

A collection of fresh-water shells from various localities in Keewatin and northern Ontario.

Macoun, J. M.:—

Collection of fresh-water shells from southern British Columbia.

Macoun, J. M. (per W. Spreadborough):—

152 skins of mammals, 249 of birds, sets of eggs of thirteen species of birds and a collection of land and fresh-water shells, from southern British Columbia.

Dowling, D. B.:—

Twenty-five fossils from quartzites of the Carboniferous and twenty from the Carboniferous limestones of the Elk Range, Rocky mountains. Two fragments of spear and arrow head from the Kananaskis river, Alberta.

Keele, Joseph :—

Nine fossils from the Upper Stewart river, Yukon Territory.

O'Sullivan, O.:—

Two marine sponges from Kettle river, south coast of Hudson bay, and specimens of twelve species of fresh-water shells from Knee lake, Keewatin.

Poole, H. S.:—

Collection of fossil plants, *mollusca and crustacea*, from the Cretaceous rocks at various localities on Vancouver island, but mostly from Nanaimo and Comox.

Cairnes, D. D.:—

A large collection of fossil plants, shells, &c., from the Cretaceous rocks of the Foot-hills of the Rocky mountains, south of the main line of the C.P.R.

The additions to the palæontological, zoological, archæological and ethnological collections in the Museum during 1905, and from other sources, are as follows.

By presentation :—

(*A.—Palæontology.*)

Springer, Hon. Frank, East Las Vegas, New Mexico :—

Six fine specimens of fossil crinoids, one from the Devonian rocks of Michigan, and five from the Lower Carboniferous rocks of Iowa and Indiana.

Grant, Colonel C. C., Hamilton, Ont. :—

Eight fossils from the Cambro-Silurian drift at Winona, and thirty-four from the Niagara formation at Hamilton and Grimsby, Ont.

Johnston, W. A., Athens, Ont. :—

Two good specimens and fourteen fragments of *Nanno Kingstonensis*, from Kingston Mills, Ont.

Narraway, J. E., Ottawa :—

Specimen of *Tripteroceras xiphias*, from the Black River formation near Ottawa.

Wilkins, F. W., Norwood, Ont. :—

Vertebra of dinosaur, and two other fossils, from the Belly River formation near the Battle river, Alberta.

Topley, H. N., Ottawa :—

Vertebra of *titanothere* from the Cypress hills; and two specimens of *Cyprina ovata* and one of *Baculites ovatus*, from the Cretaceous rocks thirty-five miles southeast of Irvine, Alta.

(*B.—Zoology.*)

Latchford, Hon. F. W., Ottawa :—

Seven specimens of *Unio radiatus* from the Ottawa river at Britannia; three of *Unio luteolus*, young, from the Rideau canal at Ottawa; and two of *Anodonta subcylindracea* from St. Justine, Vaudreuil county, Que.

Lambart, Hon. O. H., Ottawa :—

Flying Squirrel (*Sciuropterus volucella*) from New Edinburgh, Ottawa.

Criddle, Norman, Aweme, Manitoba :—

Mounted specimen of the Banded Pocket-mouse (*Perognathus fasciatus*) from Aweme.

Smith, John, Ottawa :—

Penis bone of seal from Ungava bay, brought some years ago by the late G. S. McTavish, of the Hudson's Bay Co. Drilled at one end and slightly carved, possibly by Eskimo.

Henderson, F. D., Ottawa :—

Skull of American bison from the province of Saskatchewan.

Dignan, Hubert, London, Ont. :—

A small living soft-shelled turtle from the waterworks at London.

Eifrig, Rev. C. W. G., Ottawa :—

Specimens of two species of *Sphærium*, from the Liévre river at High Rock, Que.

Holmes, M., Cantley, Que.:—

Star-nosed mole in the flesh, from Cantley, Wright county, Que.

Beaupre, E., Kingston, Ont. :—

Three photographs of the nest and eggs of Canadian birds.

(*C.—Archæology and Ethnology.*)

Forbes, W , Ottawa :—

Three arrow-heads, three stone adzes or skin-scrapers, and a piece of weathered rock, resembling a skin-scraper, from Cameron island, three miles from Stanley island, St. Lawrence river.

McDougall, David, Morley, Alberta, per D. B. Dowling :—

One obsidian spear head, from Morley.

Stewart, James, Grande Prairie, B. C.:—

One stone pestle, from Grande Prairie.

VERTEBRATE PALÆONTOLOGY.

Mr. Lawrence M. Lambe, (Vertebrate Palæontologist).

With the exception of part of the summer, devoted to field-work, Mr. Lambe's time during the past year has been mainly occupied in the study of the vertebrate fauna of the Oligocene deposits of the Cypress hills, Assiniboia, as represented by his collection of 1904, of which a provisional list of the contained species was given in last year's Summary. The report on the Oligocene fauna, to form part IV of volume III (quarto) of contributions to Canadian Palæontology, is fairly under way, a considerable part of the manuscript is ready, as are also a number of drawings for the plates. In anticipation of the appearance of this memoir some of the species that proved to be new to science (or of particular interest) and that it was thought advisable to describe without delay, form the subject of the following illustrated papers published during the year :—

'On the tooth-structure of *mesohippus westoni* (Cope),' American Journal of Science.

'Fossil horses of the Oligocene of the Cypress hills, Assiniboia,' Transactions Royal Society of Canada.

'A new species of Hyracodon (*H. priscidens*) from the Oligocene of the Cypress hills,' Transactions Royal Society of Canada.

Reprints of these papers have already been distributed.

The month of July and half of August was spent in the field, principally at West Maguacha, Chaleur Bay where upper Devonian rocks yielding a rich fish fauna are exposed. Here a large collection of both fish and plant remains was made to supplement those already in the possession of the Survey. This new material, when studied, is expected to add considerably to our present knowledge of the later Devonian fauna as represented in these beds. The lower Devonian rocks at Campbellton, N.B., were also visited and a small collection of vertebrate remains made therefrom. Advantage was taken of close proximity to the Lower Helderberg rocks near Little Cascapedia, Que. and at Cap Bon Ami, N. B. to add to the collections of invertebrate fossils from these localities. The collection made at Cap Bon Ami is a large and representative one and should prove an important accession to the material previously secured from this place.

Although apart from vertebrate palæontology, a short time was given to a report on fossil corals obtained by Mr. A. P. Low, at Beechey island, Southampton island and Cape Chidley, during his expedition of 1903-4 to Hudson bay and Arctic islands. This report is incorporated in Mr. Low's report as an appendix.

A large cup-shaped monaxonid sponge obtained by purchase from Mr. F. Landsberg, of Victoria, B.C., during the early part of the year was described and figured in a paper entitled 'A new recent marine sponge (*Esperella bellabensis*) from the Pacific coast of Canada.' This paper was published in the Ottawa Naturalist and reprints of it have been distributed.

Early in the year a number of excellent casts of types (or original fossils), and photographs of mounted skeletons and restorations of Tertiary vertebrates, principally from the Eocene and Miocene formations of the western States, was purchased from the American Museum of Natural History, New York. The types and photographs of skeletons are for use in studying the mammalian faunas of the Tertiary rocks, as represented by our own collections from the west, and are available, with the photographs of restorations, as an extremely interesting addition to the museum for exhibition purposes.

The casts of types or original fossils are of :—

Heptodon calciculus, Cope. Palate and lower jaws. Eocene.
Colodon dakotensis, Osborn and Wortman. Upper jaws. Oligocene.
Sytemodon primævus, Wortman. Palate and lower jaw. Eocene.
Protapirus validus, Hatcher. Skull. Oligocene.
Oreodon culbertsoni, Leidy. Fore and hind foot. Oligocene.
Hyænodon horridus, Leidy. Fore and hind foot. Oligocene.

Series of fossil horse feet and skulls illustrating the evolution of the horse :—

Hyracotherium craspedotum. Fore and hind feet. Eocene.
Mesohippus bairdi. Fore and hind feet. Oligocene.
Mesohippus copei. Hind foot. Oligocene.
Neohipparion whitneyi. Fore and hind feet. Miocene.
Protorohippus venicolus. Crushed skull and jaws. Eocene.
Mesohippus bairdi. Skull and jaws. Oligocene.
Hypohippus equinus. Skull and jaws. Miocene.
Merychippus sejunctus. Skull and jaws. Miocene.

Series of fossil camel feet illustrating the evolution of the camels and llamas :—

Protylopus petersoni. Hind limb. Eocene.
Poëbrotherium wilsoni. Fore and hind feet. Oligocene.
Protolabis montanus. Fore and hind feet. Miocene.
Alticamelus altus. Hind limb. Miocene.
Protoceras celer, Marsh. Fore and hind feet. Oligocene.
Equus complicatus, Leidy. Upper molar. Pleistocene.
Equus occidentalis, Leidy. Upper molars. Pleistocene.
Equus pectinatus, Cope. Upper molars. Pleistocene.
Equus excelsus, Leidy. Upper jaw. Pleistocene.
Neohipparion speciosum, Leidy. Upper teeth. Miocene.
Neohipparion affine, Leidy. Upper teeth. Miocene.
Neohipparion gratum, Leidy. Upper teeth. Miocene.
Neohipparion montezumæ, Leidy. Upper and lower teeth. Miocene.
Merychippus insignis, Leidy. Upper jaw. Miocene.
Protohippus (Merychippus) mirabilis., Leidy. Upper jaw. Miocene.
Protohippus perditsu, Leidy. Upper jaw. Miocene.
Protohippus supremus, Leidy. Upper teeth. Miocene.
Parahippus cognatus, Leidy. Milk teeth. Miocene.
Parahippus (Desmatipus) crenidens, Scott. Upper and lower jaws. Miocene.
Anchippus texanus, Leidy. Upper molar. Miocene.

Hypohippus affinis. Upper milk molar. Miocene.
Hypohippus (Anchitherium) equinus, Scott. Upper and lower jaw. Miocene.
Protohippus placidus, Leidy. Upper teeth. Miocene.
Mesohippus bairdi, Leidy. Skull and jaws. Oligocene.
Phenacodus primævus, Cope. Fore and hind feet. Eocene.

The photographs of mounted skeletons are of the following:—

Protorohippus venticolus, Cope. Eocene.
Cœnopus occidentalis, Leidy. Oligocene.
Protoceras celer, Marsh. Oligocene.
Oreodon culbertsoni, Leidy. Oligocene.
Hyœnodon horridus, Leidy. Oligocene.

With photographs of restorations of:—

Protoceras. Six-horned upper Oligocene ruminant.
Elotherium. Giant upper Oligocene suilline.
Megacerops. Long-horned Lower Oligocene titanothere.
Hyracodon. Cursorial Oligocene rhinoceros.
Mastodon. Pleistocene elephant.
Dryptosaurus. Carnivorous Cretaceous dinosaur.
Agathaumas. Three-horned Cretaceous dinosaur.
Madrosaurus. Duck-billed Cretaceous dinosaur.
Siberian mammoth or hairy elephant.

Note on the age of the Horsefly, Similkameen and Tranquille Tertiary Beds of the Southern Interior of British Columbia.

Among the remains of fossil fishes in the Museum of this department are a number of specimens from Horsefly river, from the North Fork of the Similkameen river and from near Tranquille, Kamloops lake; three widely separated localities in the southern interior of British Columbia. The recognition, lately, by the writer of a second specimen of *Amyzon brevipinne*, Cope, in the small collection from Horsefly river points to the probable synchronism of the sedimentary rocks in which the fossils at this locality occur with the Amyzon beds of Colorado and Nevada. The other fishes contained in the Horsefly River collection are referable to Cope's species *Amyzon commune*. characteristic of the Amyzon beds of Colorado.

The beds on the North fork of the Similkameen river from which remains of plants, insects and fish were obtained by Dr. George M. Dawson have, on the evidence of these fossils, been regarded as 'probably of Oligocene (later Eocene age)' (Dawson, Geol. Surv. of Canada, Annual Report, vol. vii, p. 76 B, 1895). The fish remains from this locality consist of the type of *Amyzon brevipinne* (on the evidence of which Cope correlated the Similkameen beds with the Amyzon beds of Colorado and Nevada*) and a fish scale, not hitherto noticed, which agrees in size and ornamentation with those of the specimens of *A. commune*, from Horsefly river.

* Proc. Acad. Nat. Sci. Philadel., vol. xlv, p. 401, 1894.

We thus have two species of Amyzon common to, and comprising the known fish fauna of the Horsefly and Similkameen beds.

Also it is probable that the beds near Tranquille belong to the same horizon as those of the Horsefly and Similkameen rivers as the fish remains from this first locality are apparently referable to *Amyzon commune.*

We may conclude, then, that the fish-bearing deposits of the above three localities are probably of the same age and synchronous with the Amyzon beds to the south of the International Boundary.

A description of the structure of *Amyzon brevipinne* based on the specimen of this species from Horsefly river will shortly appear in a paper by the writer.

The Botany and Climate of the Northwest Side of the Lower St. Lawrence

Professor John Macoun.

After my Summary Report for 1904 was written I continued to work on the Rocky Mountain flora and prepared a series of specimens for exhibition at Lake Louise, Field and Glacier in the Rocky and Selkirk mountains. An exhaustive work on the botany of the Rocky mountains, south of the International Boundary, is being prepared in the United States and as this is designed to include southeastern British Columbia and Alberta it has, meanwhile, been considered wiser to defer the completion of my report. The publication of Mr. A. O. Wheeler's work on the Selkirk mountains, for which I wrote a short account of the fauna and flora of those mountains, and the popular flora of the Rocky and Selkirk mountains by Mrs. Julia Henshaw, now in the press, so completely cover the ground in a popular sense that there is no urgent need of a more technical work.

Last spring you decided that, owing to our fragmentary knowledge of the flora and fauna of the St. Lawrence valley below Quebec, it might throw much light on the climatic conditions existing there if a study of its flora were undertaken. The only collections of plants we had from that region were those made by Dr. John Bell in 1862 and by the writer in 1882. Both collections came from the Gaspé peninsula.

Following out this decision, I left Ottawa on June 19th and made my headquarters at Montmorency Falls, extending my examinations to Quebec on the one hand and St. Joachim on the other. I worked here until July 12th, after which I made my headquarters at Cap à l'Aigle. From this point I examined the district west of Murray Bay and river and eastward to Port à Persis, which is some distance west of Tadousac. I remained here until August 31 reaching Ottawa on September 2. The season was very successful and large collections were made of plants of all kinds; at the same time the climatic conditions, and the many problems presented by the peculiarities observed were noticed. In making my collections I was assisted for the greater part of the time by Mr. Roy Cameron, of this city. A detailed report on the work done will be submitted as soon as possible.

After returning from the field I was occupied for two months making a collection of nearly 700 species of the fungi of the Ottawa district. Afterwards, collections made during the summer were carefully examined and presented many rare and interesting forms. The coldness of the water gave arctic sea-weeds, while the flora of the hill-sides indicated a summer temperature much higher than had been anticipated.

The arrangement of a Catalogue of the Mammals of the Dominion, on the same lines as that of the Bird Catalogue, has been commenced, and will be prosecuted steadily when other work will permit.

Botanical Work on the Southern Boundary of British Columbia.

Mr. J. M. Macoun.

Between the date of my Summary Report for 1904 and my departure for the field in May my time was occupied in the routine office work and in the determination of specimens collected by me and others during the previous season. The " Flora of the Hudson Bay region " was also completed and is now ready for the press.

Pursuant to your instructions I made arrangements to spend the collecting season of 1905 in British Columbia, in the vicinity of the International Boundary. Early in April my field assistant, Mr. W. Spreadborough, joined one of the survey parties at work in the vicinity of Midway, where I joined him later, and proceeded thence to Mr. Ogilvie's camp at Rock creek. From the end of May until the middle of August I either camped with him or was given supplies and transport by him, and every facility was afforded me for the successful prosecution of my work. After my arrival, Mr. Spreadborough's time was devoted chiefly to the collection under my direction of birds and mammals, while my own labours were given to botany. Following the old Dewdney trail, we crossed the country between Midway and the Skagit river, spending several weeks in the vicinity of Osooyos lake. Less was known of this region, from a natural history point of view, than of any other part of British Columbia, and several birds and small mammals not before collected in Canada were secured, as well as many new plants—some new to science, others not previously recognized in Canada.

The month of July and part of August was spent in the Skagit valley and on the mountains between the Skagit river and Chilliwack lake. These mountains were found to be the district in which several groups of small mammals intermingled. The flora was that characteristic of the mountains farther west but several new species of flowering plants were discovered. Leaving Mr. Spreadborough to complete the season's work I returned to Ottawa August 22nd and after working a few days in the office took advantage of the fine weather to study the aquatic plants in the streams near Ottawa. The collections made last September will, with our previous knowledge, enable us at any time to write a full report on these plants.

Since returning to the office I have been engaged in naming specimens sent in by collectors and in working up my own collections.

Office Work.

During the year 4,441 sheets of botanical specimens were sent to herbariums in different parts of the world, chiefly to government or university museums, in exchange for specimens received. These latter numbered more than 2,000. A larger number of specimens than usual were mounted and placed in our herbarium—4,799 in all.

Eight hundred and nineteen official letters were written and about the same number were received.

MAPPING AND ENGRAVING.

Mr. C.-O. Senécal, Geographer and Chief Draughtsman.

The following is a statement of the work carried out under the supervision of the Geographer and Chief Draughtsman during the past calendar year :—

Mr. L. N. Richard completed the plotting of the Nova Scotia traverse lines run in 1904 and laid out base-lines for sheets Nos. 84, 85, 88, 95, 96, 97, 98, 103 and 104 N.S.; he completed the map of Montreal and vicinity for engraving, revised the compilation of Ignace sheet (No. 5 N.W. Ont.) which he also prepared for engraving and lithographing.

Mr. Richard left for the field on the 24th of June, under instructions to run transit and chain traverse lines in Nova Scotia along the D. A. Ry. between Middleton and Digby, along the Caledonia Branch of the H. & S. W. Ry. and along the Liverpool road between Parkers cove on the Bay of Fundy to Liverpool bay on the Atlantic. About 200 miles of railway and road were surveyed, the plotting of which will be available as base-lines for the construction of Sheets Nos. 90 to 121. Mr. Richard is at present drawing a map of the shore-lines of the Ancient Great Lakes in Ontario for the Summary Report of the Department for the past year.

Mr. O. E. Prud'homme made additions to the Ottawa and Cornwall sheet (No. 120 Ont. and Que.), traced and lettered Pembroke sheet (No. 119 Ont.) Gay River and Musquodoboit Harbour sheets (Nos. 54 and 55 N.S.), for engraving, and prepared the copy for photolithographic reproduction of the maps of Nicola Valley Coal Fields, B.C., Yamaska mountain, Que. and Nictaux-Torbrook Iron district, N.S.

Mr. J. A. Robert calculated latitudes and departures of the traverses run in Nova Scotia in 1904 and part of those run in 1905. He revised the Nova Scotia sheets Nos. 59, 60, 61 and 62, and worked on the compilation of Mr. Fletcher's surveys on Sheets Nos. 83, 84, 85, 98, 99 and 103, which are at present fairly advanced. He compiled the maps of Nictaux-Torbrook district, N.S., and of Chibougamau region, Quebec, and traced the latter for engraving.

Mr. H. Lefebvre was appointed on the permanent staff and reported himself for duty on the 31st of January. He compiled and traced for engraving the Brome Mountain map and prepared the copy for photolithographic reproduction of the map of the Kluane Mining district, B.C. and of the West Coast of James bay. He assisted Mr.

D. B. Dowling in the compilation of that officer's phototopographic maps of the Cascade Coal Basin, Alberta, and traced the four following sheets of this map for engraving, viz.: (No. 1, Panther River sheet; No. 2, Cascade River sheet; No. 3, Canmore sheet, and No. 4, Wind Mountain sheet).

Mr. F. O'Farrell continued the compilation of Mr. E. R. Faribault's Nova Scotia surveys on the 1 mile scale. He compiled Sheets Nos. 70 to 73 incl.; revised Sheets Nos. 66 to 69, and commenced Sheets Nos. 86 to 89. During the summer Mr. O'Farrell accompanied Mr. Faribault in Nova Scotia and assisted this officer in the revision of his map work.

Mr. P. Fréreault completed the compilation and made the tracing for engraving of the map of Northeastern Canada on the scale of 50 miles to an inch, prepared the copy for photolithographic reproduction of the maps of Duncan creek, Yukon territory, Costigan Coal Field, Alberta, and nine diagrams to accompany various reports.

Mr. V. Perrin assisted Mr. Wm. McInnes in the mapping of his surveys of the Winisk river and attended to general work. He resigned in March.

Mr. A. Dickison has been employed on the temporary staff of this office since the 3rd of July. He reduced the published and unpublished geological surveys of Nova Scotia to the scales of 4 and 8 miles to 1 inch and constructed two maps to accompany a special report on Nova Scotia. The engraver's copy of these maps is nearing completion. He also traced and lettered a map of Yukon territory for the Summary Report, 1905.

Mr. J. J. McGee, jr., was employed as general assistant and typewriter. He attended to the classification of records and made sundry tracings for office and field use. He accompanied Mr. Richard last summer in the field as chainman.

The following maps were compiled by field officers from their respective surveys:—

The Yukon Territory (including a survey of Peel river by C. Camsell), scale 32 miles to 1 inch, Mr. J. Keele.

The Cascade Coal Basin, Alberta, scale 1 mile to 1 inch (4 sheets, Topographical and Geological editions), Mr. D. B. Dowling.

The Moose Mountain Region, Southern Alberta, scale 2 miles to 1 inch, Mr. D. D. Cairnes.

The Southwest Coast of Hudson Bay, scale 16 miles to 1 inch, Mr. O. O'Sullivan.

Progress work on 8 mile map of Northwestern Ontario, Messrs. W. J. Wilson, W. H. Collins.

Revision of Sheets Nos. 53, 54 and 55. Progress work on Sheets 66, 67, 72 and 73, Nova Scotia, scale 1 mile to 1 inch, Mr. E. R. Faribault.

The routine work of laying down geographical projections, making photographic reductions of maps, sun prints, tracings, list of repairs, etc., was divided among the staff and attended to.

The meetings of the Geographic Board were regularly attended as usual.

The following three maps accompany the Summary Report for the past year, viz. :—

No. 915. Southwest Coast of Hudson Bay, scale 16 miles to 1 inch.

No. 916. Windy Arm Mining District, B.C., scale 2 miles to 1 inch.

No. 917. Yukon Territory, scale 32 miles to 1 inch.

Besides the above mentioned maps, there are about twenty in the hands of the King's Printer at various stages of progress, including the copper plate editions of twelve sheets of the Nova Scotia systematic series on the scale of 1 mile to 1 inch, the last proofs of which have been revised and are ready for the press. It has been deemed advisable to hold over many of these sheets until the colours of the full set have been thoroughly revised and to have them printed together at one time in order to secure uniformity in the geological tints.

The edition of the following maps and diagrams was received from the King's Printer during the past calendar year :—

Catalogue number.	Description.	Area in square miles
885	Yukon Territory—Klondike District and Vicinity Showing Water Supply. Scale 8 miles to 1 inch....	
886	Yukon Territory—Distribution of Auriferous Gravels in Klondike Mining District. Scale 2 miles to 1 inch....	About 1,300
772	Yukon Territory—Geological Map of Klondike Mining District. Scale 2 miles to 1 inch....	" 1,300
891	Yukon Territory—Duncan Creek Mining District. Scale 6 miles to 1 inch....	
894	Yukon Territory—Sketch Map, Kluane Mining District. Scale 6 miles to 1 inch....	" 2,500
834	British Columbia—Economic Minerals in Boundary Creek Mining District. Scale 1 mile to 1 inch....	344
828	British Columbia—Geological Map, Boundary Creek Mining District. Scale 1 mile to 1 inch....	344
890	British Columbia—Coal Basins of Nicola Valley. Scale 1 mile to 1 inch....	
892	Alberta—Costigan Coal Field. Scale 4 miles to 1 inch....	32
889	Keewatin—Sketch Map, Lac Seul to Severn lake. Scale 35 miles to 1 inch....	
895	Ontario and Keewatin—West Coast of James Bay. Scale 16 miles to 1 inch....	
898	Ontario—Sketch Map, Bruce Mines, Desbarats District....	
770	Ontario—Geological Map of part of Hastings, Haliburton and Peterborough counties (Bancroft map). Scale 2 miles to 1 inch....	2,000
708	Ontario—Haliburton Sheet, No. 118. Scale 4 miles to 1 inch....	3.456
874	Quebec—Geological Map, and Section, Island of Montreal and Vicinity. Scale 4 miles to 1 inch....	1,850
887	Quebec—Geological Map, Yamaska Mountain. Scale 20 chains to 1 inch....	12
901	Quebec—Geological Map, Brome Mountain. Scale 40 chains to 1 inch....	90
867	Nova Scotia—Wine Harbour Gold District. Scale 250 feet to 1 inch....	
897	Nova Scotia—Nictaux-Torbrook Iron District. Scale 25 chains to 1 inch....	
	Eight diagrams showing Mineral Production to 1903 inclusive....	
	One diagram, Larose Mine, Ontario....	

The number of letters, memoranda, specification sheets, &c., relating to map work was 220 sent and 175 received.

The Library.

Dr. John Thorburn, Librarian.

During the year, from January 2nd to December 30th, 1905, there were distributed 13,861 publications of the Geological Survey, comprising reports, parts of reports, special reports and maps; of these 13,358 were distributed in Canada, the remainder, 503, in foreign countries, as exchanges to universities, scientific and literary institutions, and to individuals engaged in scientific pursuits. The reason why comparatively few publications were sent to foreign countries was because the Annual Report; Vol. XIV, has not yet been issued, although it has been in the printer's hands for several months.

The sale of publications during the year, including reports and maps, amounted to $663.19. As will be seen, the amount received has been gradually decreasing. This is owing to the fact that, for some years past, the free distribution has been on a more liberal scale than was the case previously.

There were received, as exchanges or donations to the library, 3,247 publications, including reports, transactions, proceedings, memoirs, periodicals and maps. The volumes purchased during the year were 715, and 54 scientific periodicals were subscribed for. The number of letters received in connexion with the library was 2,905, besides 1,536 acknowledgments from exchanges and individuals. The number of letters sent from the library was 2,664, besides 665 acknowledgments for publications received.

There are now in the library about 15,500 volumes, in addition to a large number of pamphlets on various subjects.

The number of volumes that were bound during the year was 385.

The library is open from 10 a.m to 4 p.m. for persons wishing to obtain information in regard to scientific subjects.

Mrs. J. Alexander is assistant librarian, and has charge of the cataloguing and shelf arrangement of the books.

Much of her time is occupied in supplying information to inquirers regarding survey publications and in assisting members of the staff to find literature bearing on the work in which they are engaged.

Miss Barry has charge of the distribution books and of the exchange lists, besides the acknowledgments received for publications sent out. She also has charge of the filing of letters relating to the work in the library. Apart from her duties in the library, Miss Barry keeps a record of the non-attendance of the permanent and temporary members of the survey staff.

During part of the day Miss Stewart typewrites the letters sent out having reference to the library. These are constantly increasing, as may be seen by comparing the numbers sent out for some years past.

Miss Alexander enters all publications received in the accession book, and attends to the indices. She acknowledges all publications received by presentation, and assists in typewriting.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The staff at présent employed numbers 67.

The funds available for the work and expenditure of the department during the fiscal year ending June 30, 1905, were :—

Details.		Grant.	Expenditure.
		$ cts.	$ cts.
Civil-list appropriation		63,075 00	
General appropriations		113,815 25	
Civil-list salaries			58,129 29
Explorations and surveys			27,529 22
Wages of temporary employees			26,860 47
Printing, engraving and lithographing			17,605 54
Books and instruments			5,430 78
Chemicals and apparatus			484 54
Specimens for Museum			6,589 10
Stationery, mapping materials, &c			2,169 57
Incidental and other expenses			3,565 93
Advances to explorers			40,065 96
			188,430 40
Less—Advanced in 1903–04 on account of 1904–05	$19,202 50		
Deduct—Unexpended advances credited Casual Revenue	855 07		18,347 43
			170,082 97
Unexpended balance Civil-list appropriation			4,945 71
" General "			1,861 57
		176,890 25	176,890 25

The correspondence of the department shows a total of 13,125 letters sent, and 13,904 received.

I have the honour to be, sir,

Your obedient servant,

ROBERT BELL,

Acting Deputy Head and Director.

OTTAWA, April, 1906.